POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

Contents

Prime Movers 424
With the Editors 425
Meetings Made Helpful. New Blood
Largest REA Plant Starts Service. By E. B. Wayts 426
Modern Turbines. By L. E. Newman 431
To Keep Superheaters Clean 435
New 400-lb. Unit for New Haven Pulp & Board 436
Burning Indiana Coal on Industrial Stokers. By L. F. Lang 440
Measuring Ten Millionths of an Inch 441
Modern Utility Stations. IV. American Gas and Electric System. By James A. Powell 442
Diesel Power Station Operation. By John M. Drabelle 449
Investment Returned 34 Per Cent. By Harry P. Dempsey 451
Electron Tubes—Principles and Applications Part XXVII. By A. W. Kramer 456
Gas Immersion Steam Boiler 460
Metallic Vapor Lamps Well Rooted. By Samuel G. Hibben 461
Residential Load of Growing Importance to Utilities 462
Oil Free Compressed Air 467
Pipe Welding Costs and Data. By A. F. Davis 468
Readers' Conference 470
New Equipment 474
News from the Field 479
For the Engineer's Library 481
New Engineering Books 483
Power Plant Construction News 484

Contents of back issues of Power Plant Engineering will be found in Industrial Arts Index on file in Public Libraries.

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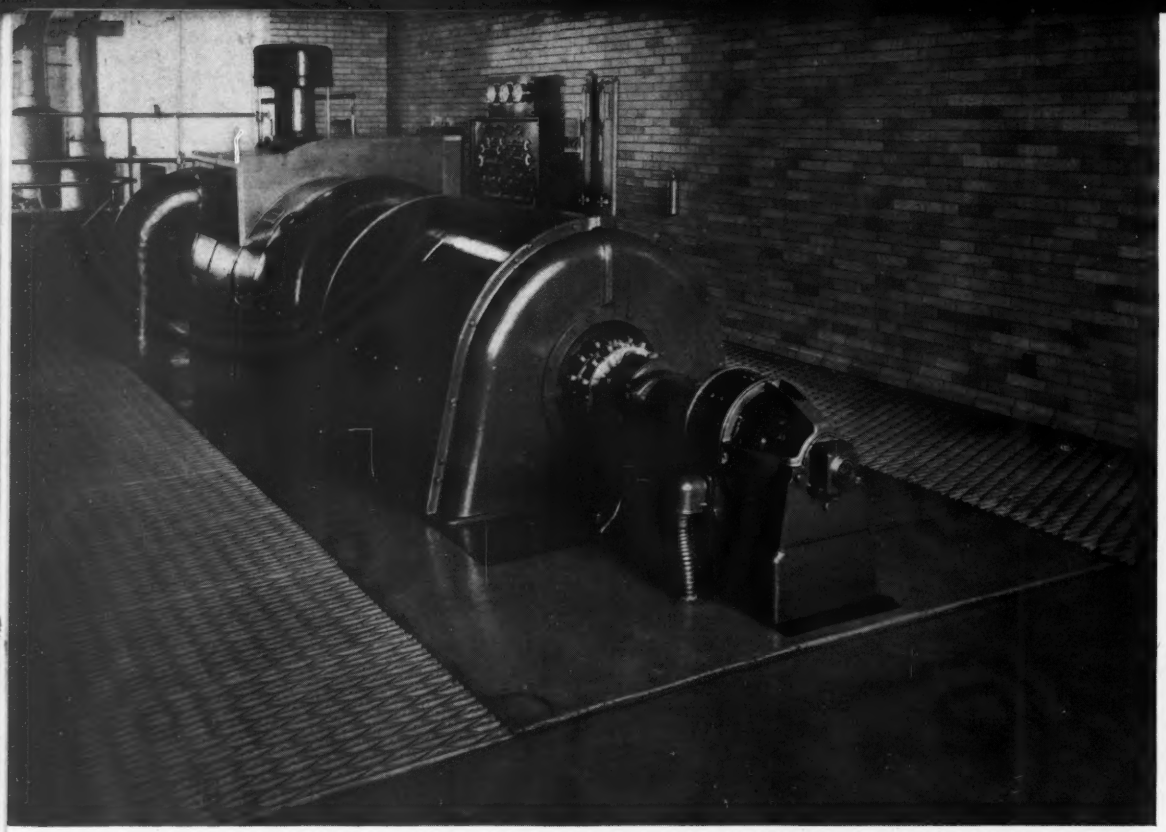

1250 kw. turbine-generator set at the Worthington, Minn., Municipal Plant.

PRIME MOVER

"OF ALL PRIME MOVERS, the turbine is the most flexible." Until we read this statement in the first article on Modern Turbines in the September issue we admit we never gave the matter much thought—sort of took it for granted, no doubt, as one does one's wife or one's breakfast—but the more we read these articles by Mr. Newman the more do we appreciate its significance. These articles in fact have given us a new respect for the turbine and have provided us with a richer background against which to place a picture such as is shown above. This, to be sure, is only an industrial turbine not essentially different from thousands of others installed all over the world but this very fact makes it remarkable. The turbine can be adapted to almost any condition or group of conditions existing in industrial plants of the most varying natures. It is the only prime mover capable of being built in the thousands of different designs necessary to meet the wide diversity of industrial applications and what is more remarkable, these thousands of different designs are built by combination of relatively few standard parts.

Among the things that Mr. Newman has pointed out in these articles the following are of particular interest. The turbine is the simplest of all prime movers. It was the first to be invented and the last to be developed. It is the most flexible; no other prime mover can be built more tiny nor none as large. It converts steam hot enough to set fire to a piece of wood into steam too cool for a bath in less than a half second. Compared to an automobile running at 30 miles per hour, a turbine geared directly to the wheels would cover a distance of 250,000 miles the first year and even then would not be ready for its first inspection. The weight of steam passing through a turbine every hour is often equal to several times the weight of the machine itself. In the absence of a governor to control the speed, if the full load were suddenly dumped from a 5000 kw. generator, the turbine would accelarate to reach double speed in less than six seconds.

Since March, Mr. Newman has stepped aside temporarily to let Mr. Lyons discuss the gadget which is usually stuck on the end of the turbine shaft and for which the turbine is made, namely the electric generator. This also is an astonishing product of human achievement and Mr. Lyons did much to enlighten us regarding some of its mysteries. Now, however, Mr. Newman is back to discuss further aspects of the turbine and in this issue he presents methods of calculating the performance of the so-called top or superposed units.

Regardless of your position or status in the power plant or in the power field, we earnestly and sincerely recommend Mr. Newman's articles to your attention.

WITH THE EDITORS

Meetings Made Helpful

NO MAN in engineering work can pass the middle of the year without being impressed with the great number of important engineering meetings and conventions that have been held, particularly in May and June. Custom and habit, no doubt, have much to do with the arrangement of these national meetings with an occasional breaking away from the particular society's program order. The ostensible reason for holding an engineering meeting is for the discussion of the problems of the day, and these vary from year to year with advances in research, changes in the use of materials, new designs of equipment, revised methods of operation, and progress toward a better understanding of management problems. There are, however, by-products which, to many who attend, are productive of more value than the technical sessions of the convention and it is to these additional features that the engineer must turn his attention when summarizing the worthwhileness of a meeting he has attended.

Nearly all of the national societies make a practice of publishing the prepared papers that are presented, usually in abstract, at their meetings. These copies are available to members and others at little or no expense, the privilege, however, of entering a direct discussion of the paper with the author is open only to those who attend the meeting. Thus it is possible for an observant man in the audience frequently to learn who has encountered problems similar to his own and how these difficulties are being met. Leaders of engineering thought make it a point to follow up these discussions by personal acquaintance and correspondence which are frequently productive of research investigations and contributions to available engineering data. With proper approach, any engineer having original ideas that he has put into successful operation, will find at these meetings an opportunity to place them before an appreciative audience, capable not only of criticising but of improving the work that has already been done. It may be stated as almost axiomatic that the man who brings most to a technical session takes the most away.

While topics for papers are usually selected by committees familiar with the problems of the day, it frequently happens that other problems are brought up in discussions and suggest investigations along entirely different lines. It is impossible, therefore, to judge, by reading the preprints of papers, all the topics that will come up in the meetings.

Frequently an engineer will find that suggestions for the solution of some of his problems will come in personal conversations with men in similar work while on inspection trips, in hotel lobbies or even at social events. To the man seeking information, a national meeting of the leaders in his profession should prove to be an invaluable source if he would cultivate acquaintance by sharing experiences and helpful data with others who can use them.

New Blood

FROM the engineering colleges of the country have come, during the past month, hundreds if not thousands of young men to swell the ranks of the engineering profession. With unemployment reported to be the highest it has ever been, industry is disposed to look upon these young graduates as unwelcome newcomers seeking to displace many of those who are now filling places which have been earned by long and faithful service. Unfortunately that displacement will take place in many cases by reason of survival of the fittest, rather than any unreasonable desire on the part of the young men to replace those already at work.

Just as factories and power plants seek to keep their equipment up to date by the installation of the latest designs, so industry is compelled by force of competition to keep its ranks of employes filled with new blood, young men equipped with a full fledged specialized education and fired with ambition to make a success of any undertaking opportunity may offer.

In the power plant field there is need, from one end of this country to the other, for the application of the newer scientific principles that have been developed during recent years in laboratories and proved advantageous in the most advanced plants of the country. Physics, chemistry, mathematics, thermodynamics, heat cycles, electronics, metallurgy are all equipped with new tools, the elements of which are known to young men seeking to be recruits in the field. It would seem the part of wisdom not to replace the experienced engineers, who have proved their worth in the plant, with the young men, but to place by their sides the new tools of science in the possession of college graduates. There is nothing new about the apprenticeship system in industry but the advancing use of scientific principles in power plant engineering has taken this occupation beyond the class of a trade and the ordinary trades apprenticeship must be considered as supplementary to the theoretical training secured in college.

Largest

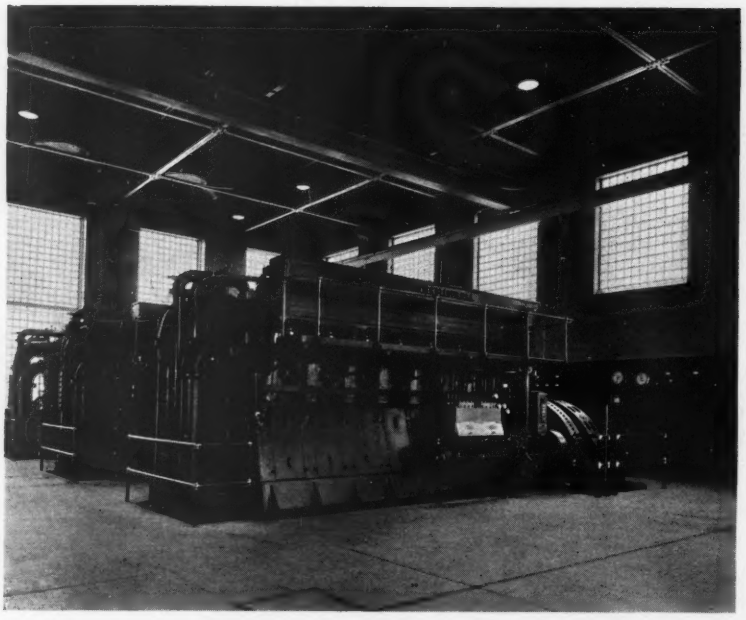

Fig. 1. Construction work on this plant with three 700 kw. Diesel generating units and located about 5 mi. north of Chippewa Falls in the heart of Wisconsin's hydro district was started November 10, 1937. It was first operated on March 11, 1938 and officially opened May 22

DURING JANUARY 1935, the President issued an executive order to the Relief Administration to make a survey of the States as to the feasibility of Rural Electrification. This work, started in Wisconsin in February, was completed August 1, 1935, at a cost of $40,000 and covered 1665 surveyors townships. From these survey maps, several projects in the state were made up and submitted to REA at Washington for approval and allotment. In October 1935 Governor LaFollette inaugurated the office of Rural Electrification Coördination for the purpose of aiding farmers in organizing projects correlating their plans with the REA at Washington.

In April, 1936, the organized groups of the Electric Coöperatives formed the Wisconsin Rural Electric Coöperative Association for the purpose of engineering, supervising and advisory service. The writer was appointed chief engineer of this new organization, the first of its kind to be created in this country. On May 2, 1936, the first allotment was made to Richland Coöperative Electric Association and on September 7 a celebration was held at Richland Center to witness the setting of the first REA pole in the state.

Project Financed By Government Loans

In May, 1937, the Wisconsin Power Coöperative was organized to build a power plant and transmission line to sell power at wholesale to local projects within a radius of about 70 mi. At present the area, Fig. 2, includes 10 projects in 11 counties, and reaches approximately 10,000 farmers. The Board of fifteen Directors is selected from officials of the ten member projects, namely: The Buffalo County Electric Coöperative; The Chippewa Valley Elec. Coop.; The Clark Elec. Coop.; The Dunn County Elec. Coop.; The Eau Claire Elec. Coop.; The Jackson Elec. Coop.; The Pierce-Pepin Elec. Coop.; The St. Croix Elec. Coop.; The Taylor County Elec. Coop.; The Trempealeau Elec. Coop.

A loan agreement with the REA was signed on June 1, 1937, and on the same day the Banister Engineering Co. of St. Paul, Minn., and Hudson, Wis., was retained to design and supervise the construction of the generating plant. Plans and specifications were prepared in close cooperation with the REA engineering staff and approved by the REA on July 28, 1937. Equipment and building bids were received at various dates between August 16 and October 11 and ground was broken at the plant site on November 7, 1937. The first engine was started on March 11, 1938, and regular service on March 12.

Coincident with the plant construction, the Wisconsin Power Coöperative built 243 mi. of 33 kv. transmission lines with substations at strategic locations, and the local coöperatives built some 2250 mi. of 6900 v. distribution lines. As shown by the map, Fig. 2, the transmission system is roughly T shaped and is divided into three legs: the east, which was completely energized on March 16, the south leg energized March 14 and the west leg energized on May 21. The plant, centrally located about 5 mi. north of Chippewa Falls and adjacent to the C. St. P. M. & O. R. R. at what is now known as Reaspur, includes building facilities for more than double the present capacity.

An exterior view of the station is shown by Fig. 7 and a small scale property plot of the station site by

Table I. Summary of acceptance tests on the engines

Average Load				Pounds of Fuel Oil	
				Per K.W.H. Corrected to 19,000 B.t.u. /Lb. Unity P.F. Test	Per K.W.H. Unity P.F. 19,000 B.t.u./ Lb. Guarantee
K. W.	Per Cent of Unit Rating	Per Hour-Test	Per K.W.H.-Test		
354.7	50.7	212.4	0.598	.594	.625
565.8	80.8	303.3	0.536	.532	.575
703.6	100.5	387.1	0.550	.546	.555

FUEL ECONOMIES EXPRESSED IN COMMERCIAL TERMS

Per Cent Load	K.W.H. Per Gallon Fuel Oil	
	1.0 P.F.	0.8 P.F.
50.7	12.9	12.8
80.8	14.4	14.3
100.5	14.1	14.0

REA Plant Starts Service

Wisconsin Power Cooperative builds new 2100 kw. Diesel station to supply power at wholesale to 10 cooperative electric associations in 11 counties of western Wisconsin. Constructed in 5 mo., it is one of the first of several plants, built in the country under the REA exclusively for rural electrification, to go into service and it is the only one in the state of Wisconsin.

By E. B. WAYTS, Manager

Wisconsin Power Cooperative
Chippewa Falls, Wis.

Fig. 3. At the left of the station is the 33 kv. steel substation with the transformers connected to the station bus by underground cables. At the right of the station is the Marley cooling tower and immediately in front of it a 5000 gal. clean fuel oil tank and a soft water reservoir. Two 30,000 gal. fuel oil storage tanks are in the immediate foreground adjacent to the tracks. The three tanks and reservoir are underground but the positions are indicated in Fig. 3 and they can be located on the photograph by means of the vent pipes and covers.

Building

The building is of concrete, structural steel and buff face brick construction, with Wisconsin sandstone coping and trim, glass block windows and full glazed tile interior finish. A flat roof construction was used, so designed that rain water can be collected and stored in the soft water reservoir for use in the engine cooling system. The main engine room, 55 by 94 ft. and sufficiently large to take care of the two future units, has a 5 t. Wright, hand operated traveling crane on a runway extending the entire length of the building to facilitate servicing the equipment. Space for the switchboard bay, workshop, store room, toilets and showers, office and display rooms, is provided in a 26 by 68 ft. space in front of the building while the Maxim silencers and air filters on the engine intakes are housed in a 9 by 53 ft. space in the back. Ventilation is provided by a duct system with both high and low intakes at either end of the building.

Generating Units

Details of the station itself are shown in large scale by the cross section Fig. 4 and the plan Fig. 5. Main generating units consist of three 1000 hp., 4 cycle, 16¼ by 24½ in., 257 r.p.m., 8 cylinder, mechanical injection Busch-Sulzer Diesel engines, each direct connected to an Electric Machinery 700 kw., 0.8 p.f., 2500 v., 3 ph., 60 cycle generator and driving a 15 kw., 125 v., 1450 r.p.m. exciter through a V-belt from the shaft. The engines are equipped with Woodward Type IC isochronous governors, automatic shut down devices for over speed and low lubricating oil pressure. A full set of alarms is installed on the cooling water and lubrication oil systems. An individual 12 point Alnor pyrometer for exhaust gas temperatures, and lubricating oil and jacket water temperatures to and from engine is located at each starting station.

All auxiliaries, tanks and coolers together with a rack for testing spray valves are located in the basement, arranged as shown by the plan, Fig. 5. The lubricating oil cleaning system consists of three tanks for new, clean and dirty oil, a Hydrol unit with electric heating elements, to heat and clean the oil, and two Viking pumps for handling the oil from and to the engines. Next to these are three starting air tanks and a Gardner Denver 2¼ by 3½ in. compressor arranged so that it may be V-belted to either a 5 hp.,

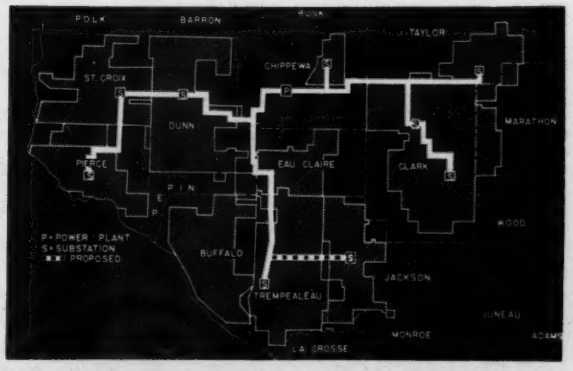

Fig. 2. Section of REC map showing the area in western Wisconsin to be served by the new plant. Some 243 mi. of 33 kv. transmission line and 2250 mi. of 6900 v. distribution lines are already constructed, and about 1100 mi. projected. The east leg of the transmission line was energized on March 16, the south leg on March 14 and the west leg on May 21

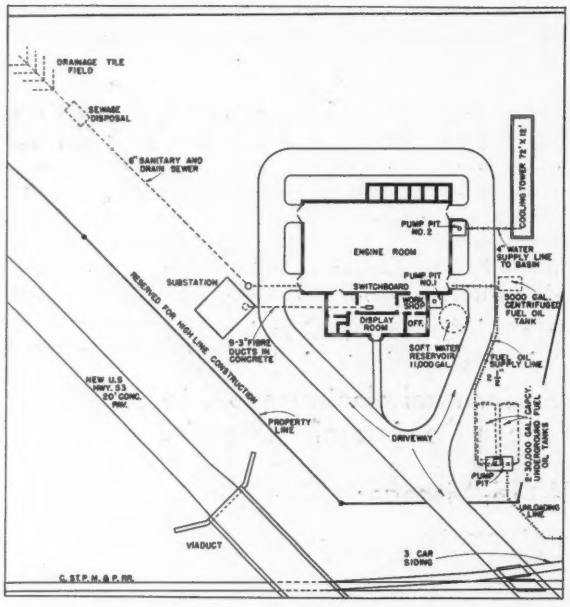

Fig. 3. The new station is located at the junction of the C. St. P. M. & O. R. R. and U. S. Highway 53. The new 3 car siding provided for tank cars has, very appropriately, been named Reaspur

1450 r.p.m. G.E. motor or a single cylinder Wisconsin gas engine. All piping, conduit and equipment are painted in accordance with the following color code: Air, white; water, green; fuel, oil, orange; lubricating oil, yellow; electric conduit, black.

Beyond the rain water collected from the roof, all water for the station systems is supplied by two wells sunk approximately 70 ft. to a sand rock formation. Four water systems are provided as explained in detail later. The hot and cold water domestic system is supplied from Well No. 2 shown in Fig. 5 while Well No. 1 is used for supplying makeup to the raw and soft engine cooling systems and to the hot water heating system used with unit heaters in the enclosed portions of the building. Although the well water is relatively soft, a Scaife zeolite softener and filter have been provided to supply makeup for the soft side of the closed engine cooling system during dry periods when the rain water supply is not sufficient.

As shown by Fig. 6 a 660 sq. ft. Ross heat exchanger has been provided for each generating unit. Three 300 g.p.m. Dayton Dowd pumps driven by Westinghouse 5 hp. motors and pumping into a common manifold are provided to circulate soft water through the engine jackets and oil coolers back to the heat exchangers for cooling. An elevated surge tank, provided on this system, is supplied with a float switch so that the water level is maintained automatically by a small Dayton Dowd makeup pump located in pump pit No. 1 and taking its suction from a 11,000 gal. underground soft water reservoir. This reservoir is used to store the rain water collected from the flat roof of the building and this supply is supplemented as needed by water from a Scaife zeolite softener and filter as mentioned above.

On the raw water side of the cooling system are four 500 g.p.m. Dayton Dowd centrifugals driven by 7.5 hp. Westinghouse motors. These pumps take their suction from the base of the cooling tower, pump through the heat exchangers and back to the top of the tower. The Marley cooling tower is 11 by 72 ft. and has a 5 ft. deep concrete basin. Raw water makeup is taken from a 70 ft. well by a Fairbanks, Morse deep-well centrifugal pump and delivered to the cooling tower basin or through the softener as needed. This pump is normally motor driven but an auxiliary gas engine drive is provided for emergencies. Service and domestic water is provided from Well No. 1 by a motor driven Fairbanks Morse plunger pump and an electric storage heater is provided for hot water around the building.

Fuel Oil System

The plant is served by a sidetrack with three fuel unloading stations spaced 50 ft. apart so that three cars can be spotted and unloaded at once. A 2½ in. pipe line with motor driven fuel unloading pump and meter runs to two underground fuel storage tanks of 30,000 gal. capacity each.

In the plant basement a motor driven Viking fuel transfer pump is provided to pump the oil from the storage tanks to the building with piping so arranged that the engine day tanks may be replenished, or bypassed to a 5000 gal. clean oil tank located underground, outside of plant, or, the oil can be passed

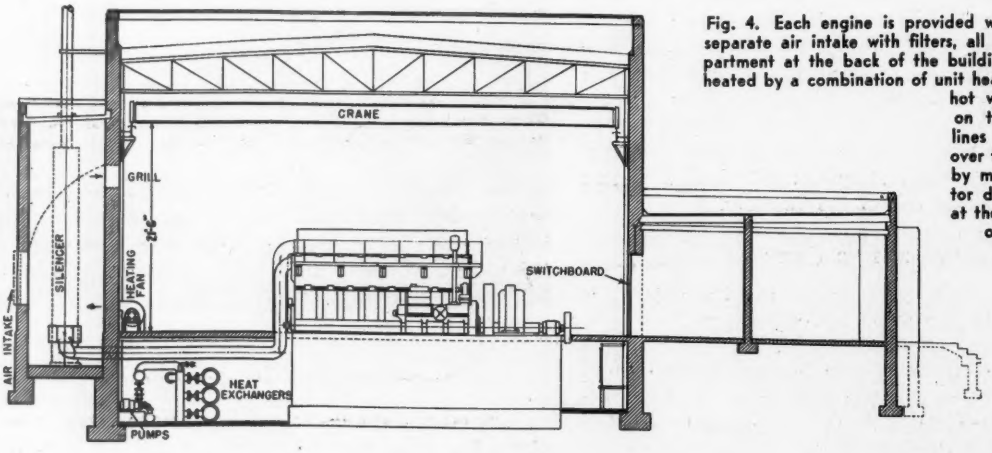

Fig. 4. Each engine is provided with a silencer and separate air intake with filters, all located in a compartment at the back of the building. The station is heated by a combination of unit heaters supplied with hot water from jackets on the engine exhaust lines and air circulation over the engine mufflers by means of three motor driven fans located at the back wall on the operating floor

through a Hydrol unit on its way to the clean oil tank.

Each engine is provided with its own day tank of about 150 gal. capacity which is equipped with an Alco Magnetic Valve and high and low level float switch to operate a common motor driven Viking fuel transfer pump. A Bowser Xacto fuel oil meter registers the amount of oil going to each engine. The fuel service tanks are located in the plant basement and by means of a small booster pump driven directly by each engine the oil is delivered to the engine fuel injection pumps through filters and under pressure. Two other sets of oil filters are provided so that fuel is filtered three times before entering the cylinders.

by pipes to Modine unit heaters, placed where heat is required.

The Westinghouse switchboard consists of three generator-exciter panels, two auxiliary panels, one feeder panel, two future generator-exciter panels and one future feeder panel. A swinging bracket carries the usual meters and synchronizing equipment. A master clock and a telechron clock form a part of the switchboard equipment. Three Westinghouse 37½ kw., 2400/240-120 v. station type transformers are located inside the switchboard bay to provide the station power.

Underground cables carry the power outside the plant to the nearby steel tower switching and trans-

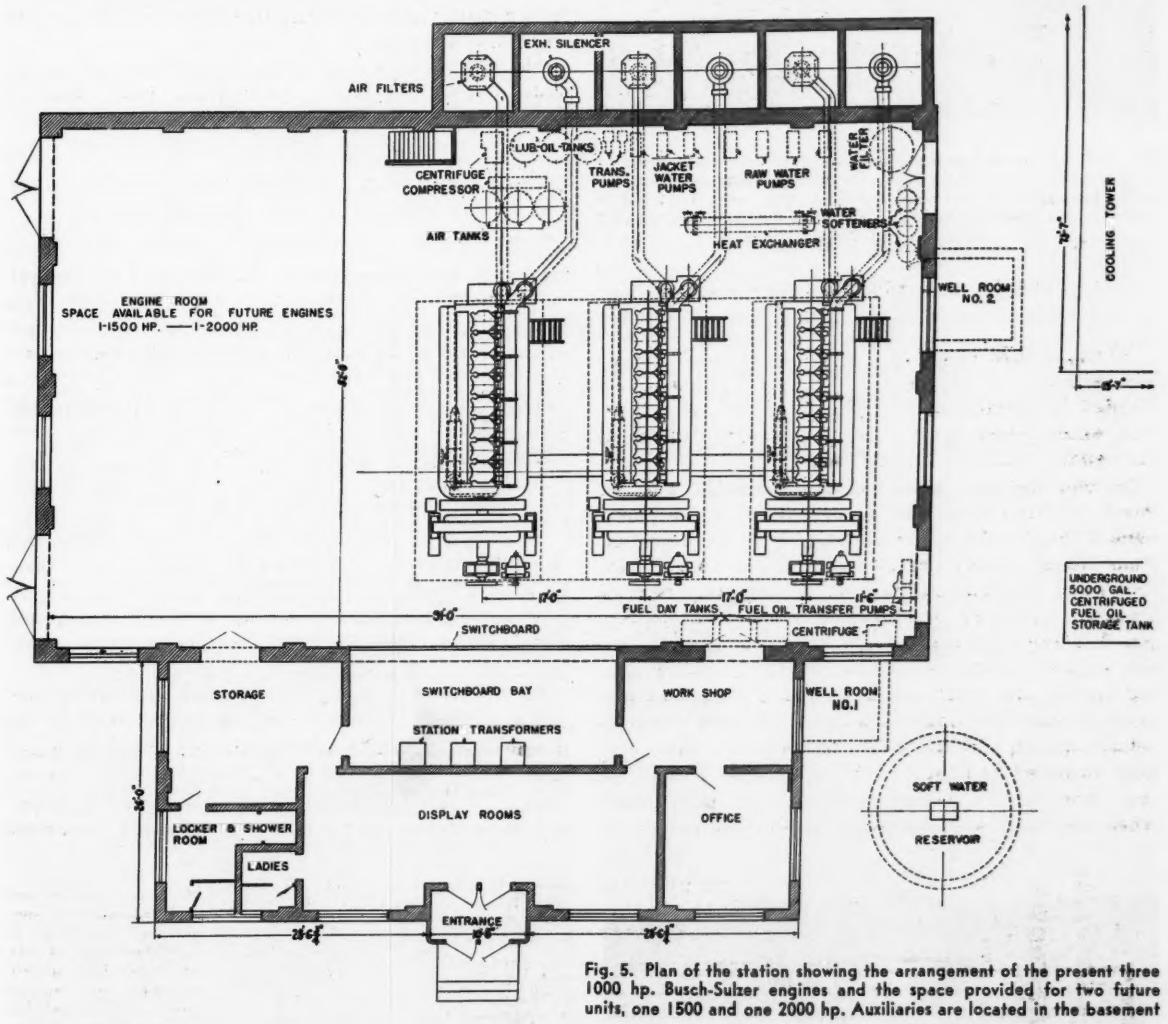

Fig. 5. Plan of the station showing the arrangement of the present three 1000 hp. Busch-Sulzer engines and the space provided for two future units, one 1500 and one 2000 hp. Auxiliaries are located in the basement

Plant heating is derived from the Diesel engine exhaust gases by two systems. Each exhaust silencer is housed in so that air from the engine room can be circulated around them by means of motor driven Sturtevant fans, thus heating the air and discharging it back into the engine room through grills in the wall.

In order to heat other parts of the building, closed off from the engine room, a section of exhaust pipe of each engine is water jacketed. The water in these sections can be separated from the main engine circulating water system and the water so heated is carried

former substation, where there are three General Electric 667 kv-a. 2500/33,000 v., grounded Y transformers. A fourth similar transformer serves as a spare. The substation is so laid out that an additional bank of transformers may be added when the system load demands.

Transmission and Distribution Lines

The main transmission lines are of standard, three-phase, flat construction with Western Cedar poles and

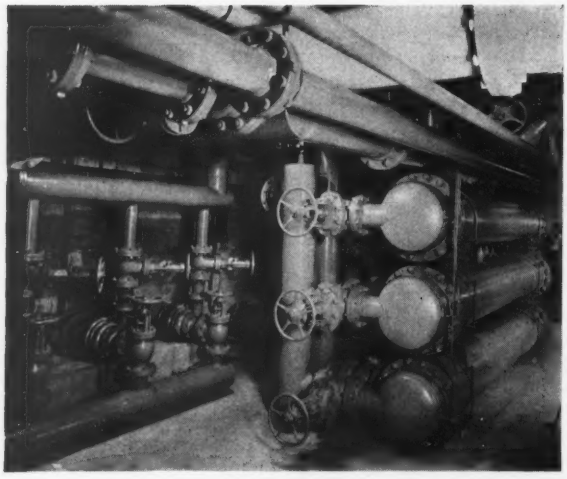

Fig. 6. The three heat exchangers, with the raw and soft water circulating pumps in the background. The water softener and filters are at the far end of the heat exchangers but only the water meter is visible in the photograph. All piping and equipment is painted with a color code for easy identification

stranded aluminum conductors. The size of conductors ranges from No. 3/0 near the generating plant down to No. 4 near the ends of the lines. 33,000 v. 3 phase, 60 cycle service is carried to each of the substations where it is transformed to 6900 v.

Single and Three Phase Distribution

Distribution systems are of the grounded Y type. Portions of the areas can be served with three phase current while single phase service is provided in other areas.

Engineering and construction was rather difficult in several of the local projects, due to irregularity of highway, hilly condition of the country, and inaccessibility of some of the farms. This work however, was very successfully planned and executed.

Fig. 7. Of brick and concrete construction with glass brick windows, the plant is a prominent feature on U. S. Highway 53 both during the day and night. Generators are connected, through oil circuit breakers and the 2500 v. station bus, with a bank of 667 kv-a., 2300/33,000 v. transformers located in the substation at the left of the plant. The cooling tower is at the right. This photograph was taken May 21 and the trucks in the yard brought out equipment and appliances used in displays during the formal opening on May 22. REA Administrator John M. Carmody was the principal speaker at the opening ceremonies

To establish fuel consumption guarantees at ½, ¾ and 4/4 loads, tests were run upon the engine generator units. In each case a 2 hr. ten per cent overload run was made following the full load test. Load was provided by means of a water rheostat and measured at the switchboard. The composite results obtained are tabulated in Table I.

Analysis of fuel oil used during tests showed the following: Heating valve, B.t.u. per lb., 18,865; special grade at 60 deg. F., 0.932 deg. Be′ at 60 deg. F., 20.2; flash point, deg. F., 217 F.; Conradson Carbon in per cent (ASTM-D-189-30), 0.95; viscosity at 100 deg. F., S.S.U., 195.

Since the plant started operation the total station power use for lighting, auxiliaries, etc., has been averaging about 121 kw-hr. per 24 hr.

LIST OF PRINCIPAL EQUIPMENT IN THE WISCONSIN POWER COOPERATIVE DIESEL PLANT

Consulting Engineers—Banister Engineering Co. Resident Engineer—L. R. Graham.
Contractors—
Building—Hoeppner-Bartlett Co.
Machinery—Busch-Sulzer Bros.-Diesel Engine Co.
Switchboard and Wiring—L. A. Kepp Contracting Co.
Engines—Busch-Sulzer Bros.-Diesel Engine Co.—Three 1000 hp., 8 cyl., 257 r.p.m., 16¼ by 24½ in. 4 cycle mechanical injection.
Generators—Electric Machinery Mfg. Co.—Three 875 kv-a., 0.8 p.f., 257 r.p.m., 2500 v., 3 ph., 60 cycle generators with 15 kw., 125 v., 1450 r.p.m. exciters driven by Gates V-Belts.
Switchboard—Westinghouse Electric & Mfg. Co.
Voltage Regulators—Ward-Leonard Electric Co.—Three electronic type.
33 kv. Circuit Breakers—General Electric Co.
2300 v. Circuit Breakers—Westinghouse Electric & Mfg. Co.
Auxiliary Transformers—Westinghouse Electric & Mfg. Co.—Three 27½ kv-a.—2400/240-120 v.
Electric Motors—General Electric Co.
Westinghouse Electric & Mfg. Co.
Motor Starters—Westinghouse Electric & Mfg. Co.
Cooling Tower—The Marley Co.—Atmospheric Spray Type.
Heat Exchangers—Ross Heater & Mfg. Co.—Three 660 sq. ft. each.
Main transformers—General Electric Co.—Four 667 kv-a., 2400/33,000 v.
Raw Water Pumps—Dayton Dowd Co.—Four 500 g.p.m. each. Direct connected to Westinghouse 7.5 hp., 240 v. motors.
Soft Water Pumps—Dayton Dowd Co.—Three 300 g.p.m. each. Direct connected to Westinghouse 5 hp. motors.
Water Softener & Filter—Wm. B. Scaife & Sons Co.
Deepwell Pumps—Fairbanks, Morse & Co.
Raw Water Meter—Buffalo Meter Co.
Soft Water Meter—Neptune Meter Co.
Soft Water Makeup Pump—Dayton Dowd Co.
Governors—Woodward Gov. Co.—Three Type IC.
Exhaust Silencers—The Maxim Silencer Co.
Pyrometers—The Illinois Testing Lab., Inc.—Alnor.
Air Filters—American Air Filters Co., Inc.
Water Regulating Valves—The Powers Reg. Co.—No. 11.
Temperature Relays—Minneapolis-Honeywell Reg. Co.
Air Compressor—Gardner-Denver Co. V-Belted to either by a 5 hp. G.E. motor or a Wisconsin single cylinder gas-driven engine.
Oil Transfer Pumps—Viking Pump Co.
Oil Meters—S. F. Bowser & Co. Inc.-Xacto.
Lub. Oil Cooler—Ross Heater & Mfg. Co.
Fuel Oil Storage Tanks—Fitts Bros.
Centrifuges—Goulds Pumps, Inc.—Hydrol.
Liquid Level Indicators—Pneumercator Co., Inc.
Valves & Fittings—Crane Co.
Heating Fans—B. F. Sturtevant Co.—Three V-Belt driven by ¾ hp. Sturtevant motors with Cutler Hammer starters.
Unit Heaters—Modine Mfg. Co.

WELL, here is Mr. Newman back on the job to tell us more about steam turbines. We have not checked up on Mr. Newman's activities since he left these pages in March but we have a sneaking suspicion he has been acting in the role of some sort of a Ponce de Leon in search of a fountain of youth for turbines, for he is back with a scheme to rejuvenate turbines. Strangely enough this scheme works; indeed, we only wish the method he suggests for old turbines could be used to give new life and vigor to our own aging bodies. How nice it would be if we could provide ourselves with a "top" a superposed heart of some sort which would add years of service to that aging organ.

MODERN TURBINES*

By
L. E. NEWMAN
Turbine Div., General Electric Co.
Lynn, Massachusetts

IN PHYSICAL SIZE superposed turbines are the dwarfs of the turbine family, but in power developed they are the giants. With all their diminutive size the quantity of steam continuously passing through them is enormous. More often than not, superposed turbines will pass several times their own weight of steam every hour. The power they develop from this steam flow is far greater than can be developed by *any* other type of turbine or any other form of prime mover, so far developed, having no greater physical size. Simple methods will be given in this article for accurately estimating these steam flows, but first let's broaden our understanding of these powerful midgets.

Superposed turbines have been a "Fountain of Youth" to obsolete steam power stations. Old, inefficient, low pressure turbines, living an expensive life of luxurious ease, have been put back to work. What couldn't be done has been done! Superposed turbines have enabled many old stations to generate well over 30 per cent more power for the same quantity of fuel burned. In many cases they have paid for themselves out of savings in amazingly short times. And they have modernized and increased the utility of existing low pressure power plants which were on the verge of honorable retirement ten years ago.

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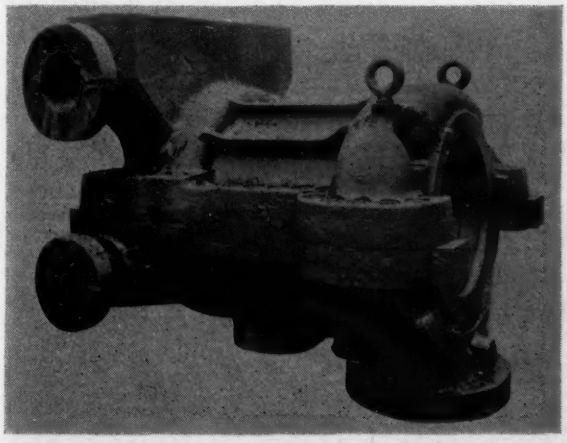


Fig. 1. Partly machined casing typical of superposed turbines rated 7500 kw. or less for main pressures of 650 to 850 lb.

Basically this rejuvenator of old plants is the familiar noncondensing turbine operating in the upper region of pressure levels. *Superposed, superimposed,* and *topping,* are all terms applied to this type of turbine to distinguish its *application* from the others. Ordinarily turbines are named by what they are; condensing, noncondensing, or extraction, and not by their relationship to other turbines. But superposed turbines derive their name from the way they are applied. They are high back pressure noncondensing turbines admitting steam at a pressure above an existing boiler pressure and exhausting this steam into a station's existing high pressure steam header or directly to the throttles of existing steam turbines. Thus they superpose, or top, the existing station's former main pressure.

Typical of such an application would be a 5000 kw. noncondensing turbine fed by steam from a new boiler at 1200 lb. pressure and exhausting this steam into an existing steam header at 300 lb. pressure. In such a case the old 300 lb. pressure boilers might be retired, or retained for standby, and the existing 300 lb. pressure turbines obtain their steam from the exhaust of the new 5000 kw. superposed turbine.

Now the station is no longer limited to obtaining power from 300 lb. pressure steam, but can take advan-

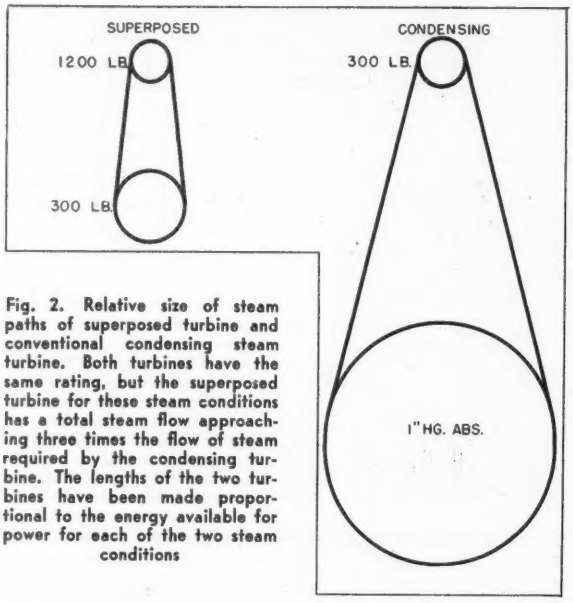


Fig. 2. Relative size of steam paths of superposed turbine and conventional condensing steam turbine. Both turbines have the same rating, but the superposed turbine for these steam conditions has a total steam flow approaching three times the flow of steam required by the condensing turbine. The lengths of the two turbines have been made proportional to the energy available for power for each of the two steam conditions

tage of the greater economy of 1200 lb. pressure operation. A new 1200 lb. power plant might have turbines taking steam at 1200 lb. and exhausting this steam to a condenser. The rejuvenated old plant would now be able to do this too, except that instead of a single turbine dropping the pressure from 1200 lb. to the condenser pressure, this drop would take place in separate turbines in two steps; first from 1200 lb. to 300 lb., then from 300 lb. to the final exhaust pressure.

Designing a turbine for pressures common to superposed turbines might be expected to produce heavy, special alloy steel casings and massive flanges. Purchasers expect these features, but are often surprised at the small size of superposed turbines. It will be recalled that for a given power output and speed, the initial pressure and final exhaust pressure are the determining factors of physical size.[1] Consider, for example, the maximum quantity of steam that can be made to flow through a nozzle with an area of only one square inch. Through this hole, about the size of a broom stick, at atmospheric pressure less than a thousand pounds of steam an hour could be made to pass. But at 1200 lb. pressure this same opening would be able to pass over 50,000 lb. of steam an hour. And, as the power output, at constant efficiency, of any steam turbine having a fixed quantity of energy available for power is proportional to the *weight* of steam flow, the influence of this factor on physical size can be appreciated. Graphically this is illustrated in Fig. 2, where the relative size of inlet and exhaust passages for a superposed turbine are contrasted with a conventional turbine of the same rating.

This comparison illustrates the further interesting fact that superposed turbines are inherently suitable for high ratings and are not feasible for low ratings. In any steam turbine efficient utilization of the energy available for power between initial and final pressure will increase with the "volume-flow" of steam. The volume-flow of steam determines the size passages required in the turbine to let the required quantity of steam pass through it. Large volume-flows require large passages which are more efficient than the small passages needed for small volume-flows. And in a superposed turbine operating with high pressure steam the steam passages are relatively small compared to the steam passages of turbines operating at lower pressures. So the only way that efficient steam paths can be obtained on superposed turbines is to build them in such large ratings that they require tremendous steam flows with steam passages increased in size accordingly. Superposed turbines have been built in ratings up to 60,000 kw., but this by no means represents the upper limit for which they could be built. The smallest feasible size for superposed turbines is about 2000 kw., but occasional cases will be encountered where superposed turbines as small as 500 kw. may show worthwhile gains. These small superposed turbines will give some improvement in the overall efficiency of the station, but they may not give sufficient improvement to justify the additional investment required for high pressures and temperatures.

Using the simplified methods given in this article, steam rates of superposed turbines in the industrial power range of sizes can be estimated within reasonable limits of error. These steam rates can be quickly estimated by anyone familiar with the terms; but not necessarily having had any special training. The charts give all the data needed, and for any given superposed

[1]Why physical size is largely determined by initial and final pressure was explained in Power Plant Engineering, Nov. 1937, Modern Turbines, beginning on Page 653.

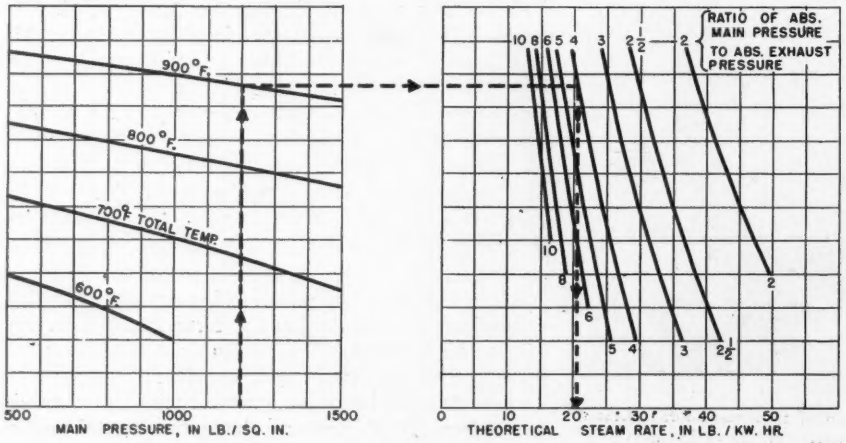


Fig. 3. Approximate theoretical steam rates for superposed turbines. Note: At sea level lb. per sq. in. A. = lb. per sq. in. G + 15

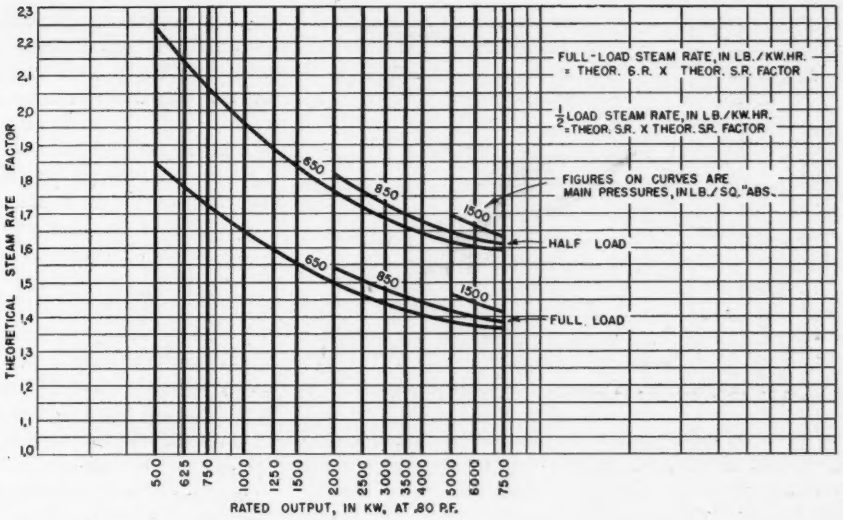

FULL-LOAD STEAM RATE, IN LB./KW.HR. = THEOR. S.R. X THEOR. S.R. FACTOR
½ LOAD STEAM RATE, IN LB./KW.HR. = THEOR. S.R. X THEOR. S.R. FACTOR
FIGURES ON CURVES ARE MAIN PRESSURES, IN LB./SQ."ABS.
HALF LOAD
FULL LOAD
650
850
1500
THEORETICAL STEAM RATE FACTOR
RATED OUTPUT, IN KW. AT .80 P.F.

Fig. 4. Approximate theoretical steam rate factors for superposed turbine generator sets

turbine-generator in the range of 500 kw. to 7500 kw., 50 or 60 cycle, a couple of minutes is all the time needed to obtain its steam rates with an error not exceeding 10 per cent. In most cases the error will not exceed 5 per cent.

The charts are limited to superposed turbines operating with constant exhaust pressure. Occasionally a new high pressure turbine is superposed on an existing lower pressure turbine in such a way as to form a cross-compound turbine generator set. The distinguishing feature of such a combination is a "floating" cross-over pressure. The exhaust pressure of the superposed turbine (i.e., cross-over pressure for the compound set) changes with load. These cases of variable exhaust pressure are not common, and the method for estimating performance of superposed turbines was therefore simplified by limiting it to the usual case wherein the exhaust pressure remains constant at all loads.

Probably the easiest way to understand the use of the charts is to work a typical example.

Let's assume for this example that the performance of a 5000 kw. superposed turbine operating with steam at 1200 lb. absolute pressure, 900 deg. F. total temperature, and exhausting at 300 lb. absolute pressure is desired. Then the known conditions are:

Rating of turbine 5000 kw.

Initial steam conditions; 1200 lb. A., 900 deg. FTT.

Exhaust pressure; 300 lb. A.

Ratio of absolute main pressure to absolute exhaust pressure is $\frac{1200}{300}$ or 4.0

Then, from Fig. 3, and Fig. 4.

Load in Kw.	TSR	TSR Factor	Estimated Steam Rate, in lb./kw. hr.
2500	20.6	1.68	34.6
5000	20.6	1.45	29.9

To obtain these estimated steam rates the theoretical steam rate was read from Fig. 3 by entering the chart at 1200 lb. A., reading to 900 deg. F. total temperature, then across to the ratio of main pressure to exhaust pressure, then down to the theoretical steam rate. This theoretical steam rate was multiplied by a theoretical steam rate factor obtained from Fig. 4. The theoretical steam rate factor was quickly read from Fig. 4 by entering the chart at the 5000 Kw. rating and reading the factors *1.45*, and *1.68*, for full load and ½ load at 1200 lb. main pressure.[2]

Having obtained the full load and one-half load steam rate of this turbine the next step is to obtain the steam rates at intermediate loads. This is easily done by simply plotting the throttle flows at full load and one-half load and drawing a straight line between them.[3] This has been done in Fig. 5 and the results put in this table.

Percent Load	Col. 1 Load in kw.	Col. 2 Steam Rate, in lb./kw. hr	Col. 3 Throttle Flow, in lb./hr.
25	1250	44.0	55,000*
50	2500	34.6	86,500
75	3750	31.5	118,000*
100	5000	29.9	149,500

Col. 3 = Col. 1 × Col. 2.

*These flows read from chart, Fig. 5, then divided by corresponding load in Column 1 to obtain the steam rate given in Column 2.

[2]Theoretical steam rate was defined and explained in the November, 1937, issue of Power Plant Engineering, Modern Turbines, Page 653.

The method for estimating steam rates of superposed turbines is a companion to the methods published in December, 1937, Power Plant Engineering, Page 741, Modern Turbines, for estimating the performance of conventional condensing and non-condensing turbines, 500 to 7500 kw., 150 to 650 lb. main pressure.

[3]Performance charts were explained in detail in the February, 1938, issue of Power Plant Engineering, Modern Turbines, Page 105.

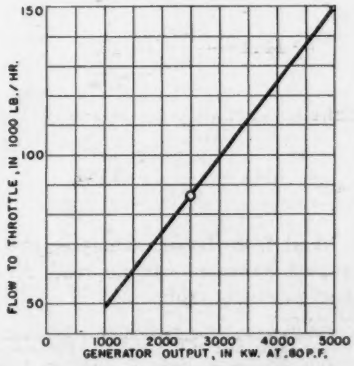


Fig. 5. Chart showing the throttle flow vs. output

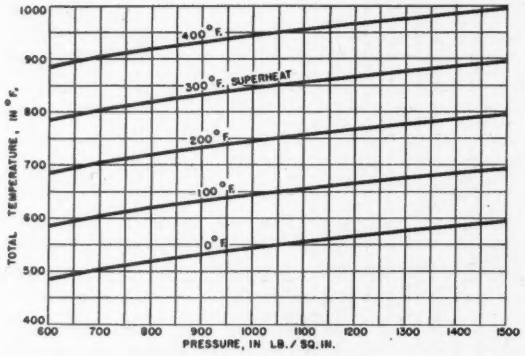


Fig. 6. Temperature and superheat of steam vs. pressure

The steam exhausted from superposed turbines usually goes to existing turbines which are limited to some maximum safe initial temperature. So it is usually necessary to determine the temperature of the steam exhausted from superposed turbines to be sure that safe limits are not exceeded on other turbines. Determining this terperature is a simple process resulting in a tabulation like this:[4]

Load in kw.	Steam Rate in lb./kw-hr.	Exhaust Enthalpy, in Btu/lb.	Exhaust Temp. in deg. F.
2500	34.6	1334	635
5000	29.9	1321	612

Exhaust enthalpy, (i.e. heat content of steam exhausted) may be estimated for any 50 or 60 cycle straight noncondensing turbine generator set rated not less than 500 kw. nor more than 7500 kw., by using the following simple formulae:

Exhaust enthalpy at 100 per cent load

$$= \text{initial enthalpy} - \frac{3600}{\text{full load steam rate}}$$

Exhaust enthalpy at 50 per cent load.

$$= \text{initial enthalpy} - \frac{3700}{\text{one-half load steam rate}}$$

In this example, and using the steam chart these equations become

Exhaust enthalpy at 100 per cent load

$$= 1441 - \frac{3600}{29.9} = 1321$$

Exhaust enthalpy at 50 per cent load

$$= 1441 - \frac{3700}{34.6} = 1334$$

And from these enthalpies the temperature at the exhaust pressure can be read directly from a steam chart or steam table.

[4]The method for determining exhaust temperature was completely explained in the March, 1938, issue of Power Plant Engineering Magazine, Modern Turbines, Page 170.

It has been the practice to specify the initial temperature of conventional turbines having initial pressures of 600 lb. or less, in terms of superheat. With the advance in main pressures and temperatures during recent years it has become more common to specify the initial *temperature* of the steam rather than the superheat. Some may prefer superheat to total temperature, and for those Fig. 6 has been included. From Fig. 6, conversion of temperature to superheat may be quickly made, and the basic charts for estimating the performance of superposed turbines will then be usable regardless of the terms in which the steam conditions are expressed.

Numerous other types of examples can be worked easily from the charts given in this article. Cases where a station has several turbines installed and needs new generating capacity may investigate their problem from the standpoint of how much additional power can be obtained from a constant steam flow at various initial pressures. Or the problem might be studied from the standpoint of what initial pressure and temperature should be selected in order to give a certain exhaust temperature. In these and many similar problems involving superposed turbines these short-cut estimating methods should prove useful and valuable.

Superposed Turbines Not a Cure-all

No attempt has been made in this article to explain the proper application of superposed turbines. Each case requires individual study by an experienced engineer or outside consultant. And, any discussion of suposed turbines is likely to create the impression that they are a panacea for all power plant ills. Moreover it is difficult to avoid creating these roseate impressions when some of the startling gains they have made possible are described. But the fact is, that superposed turbines are not cure-alls; they cannot be indiscriminately applied; their field is decidedly limited. The short cut method given in this article for estimating the performance of superposed turbines is a useful tool in the hands of a skilled workman. But like any tool, the method must be used with a broad understanding of all of the related problems in order to obtain the best results.

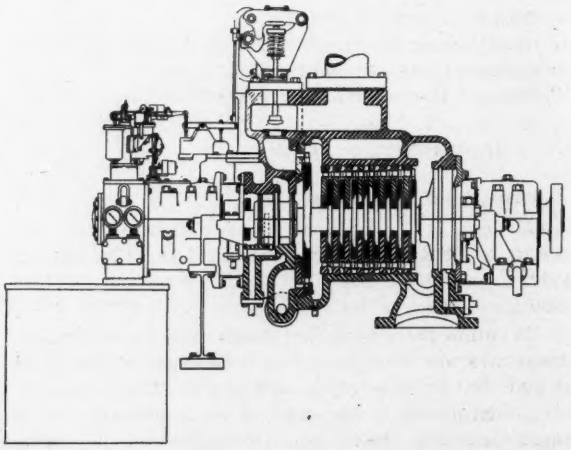


Fig. 7. Cross section of typical 5000 kw. superposed turbine

To Keep Superheaters Clean

AS IS well known, deposits in superheaters are due to the carryover of suspended matter in the steam from the boiler.

With the advent of higher operating pressures and temperatures the question of solids carryover has become increasingly important and a great amount of development work has been done to reduce carryover to practical limits.

Several causes of solids carryover are:

1. Large increases in the pounds of steam output per dollar investment, occurring more rapidly than the corresponding development of means of removing solids and moisture from the steam.

2. Lack of proper care in maintaining separating baffles tight and structurally correct.

3. High concentrations of solids in the boiler water.

4. Oil and organic matter in the boiler water.

5. Improper water level regulation.

6. Widely fluctuating plant loads and steam pressure variations.

In order to reduce solids and moisture carryover to practical limits where successful operation is maintained without trouble due to superheater deposits, the following means have been used:

1. In the past year much has been accomplished in recognizing and determining the natural physical fundamentals involved in the separation of steam and water and developing a rational analysis of the factors involved. This analysis and the experience recently obtained are now used to design properly the boiler and the internal separating mechanisms to give very low solids carryover in the steam.

2. Operating and maintenance engineers are now recognizing the importance of maintaining their equipment structurally correct.

3. Heat exchange equipment is now being used extensively to recover the heat from continuous blowdown which permits the maintenance of reasonable concentrations in the boiler water without the loss of efficiency.

4. Regardless of the care used in designing the boiler and separating baffles, it is impossible to obtain low solids and moisture carryover unless the oil and organic matter in the boiler water are kept at a very low concentration. In a number of installations this is now being accomplished by coagulating the organic matter in the makeup water with ferric sulphate or aluminum sulphate and then filtering it before going to the softener. Oil is being removed from the condensate returns by filters or separators or by replacing engine drives with turbine or motor drives.

5. Water level regulation has been improved by new designs of single element feedwater regulators and also by the adoption of two element and three element regulators which coordinate steam flow and water level.

6. In a great many cases load fluctuations have been reduced by intelligent rearrangement and control of load conditions beyond the power plant. Automatic combustion control has met with great success in maintaining practically constant operating steam pressure, all of which lessens the chance of excessive carryover.

7. On a number of installations the steam is passed through a spray or sheet of low concentration feedwater in order to reduce the solids in the steam before it enters the superheater.

The following methods have been used successfully with the boiler out of service to remove solids which have accumulated in superheaters; with modern water treatment such deposits are usually soft and can be readily washed out with hot water.

1. Completely fill the superheater with hot condensate or low concentration feedwater and leave in superheater for a few hours. Drain and repeat operation until analysis of the water shows very little increase in concentration.

2. Circulate hot condensate or low concentration feedwater through the superheater for several hours.

3. Fill the superheater with a solution of room temperature hydrochloric acid and an inhibitor and leave in superheater for several hours. Drain the acid solution and then wash out the superheater with a solution of caustic soda to neutralize the acid. Follow this with a thorough washing, using condensate or low concentration feedwater.

4. With all these methods it is very important to drain all the water from the superheater before placing a fire in the unit. In the case of a non-draining superheater the water should be blown out of each tube with compressed air.

World's Fair Lighting

GENERAL Electric's internationally famous high-voltage laboratory at Pittsfield (Mass.), where man-made lightning was first given to the world, will be transported to the New York World's Fair in 1939. For the first time in history, the general public will have an opportunity to see in action this artificial phenomenon, created for the purpose of duplicating the terrific forces of natural lightning.

The laboratory will be housed in Steinmetz Hall, named after the late Dr. Charles P. Steinmetz credited with being the father of man-made lightning. The hall will accommodate nearly 600 persons, and it will be located adjacent to the Company's "House of Magic" exhibit. The man-made lightning shows will be in charge of skilled electrical engineers, who will explain the serious purposes behind the display.

WELDING for building construction has been approved in the revision of the Chicago building code, also became legal in New York on Jan. 1, 1938. The codes define the allowable tensile, bending and compressive stresses for various parts, the strength provided being greater than that required for riveted construction.

Paper Mills are large users of electric power and steam. Because of this paper mill power plants must be so designed that these power and steam requirements can be met under various conditions of balance and load. As a consequence, the noncondensing extraction turbine is ideally fitted for use in such plants and as in the case of the installation described in this article, it is very often an important factor in reducing total power costs.

New 400 lb. Unit For N. H. Pulp and Board Co.

SOME EIGHT YEARS AGO, in February 1930 to be exact, there appeared in these pages a description of a new power plant built for the New Haven Pulp and Board Co. at New Haven, Conn. This plant, it may be recalled by those who read the article, was built to replace an older installation which was no longer able to supply the growing load demands of the paper mill.

This new plant involved a 400 lb. pressure, stoker-fired boiler and a 2500 kv-a. non-condensing, extraction turbine and replaced an old Corliss engine and a 1500 kw. turbogenerator supplied with 150 lb. steam by a number of small boilers. The old Corliss engine was removed to make room for the 2500 kv-a. extraction turbine, but the 1500 kw. turbine and the small boilers were retained for standby service.

Since this installation in 1929, the high pressure boiler and turbine have carried the entire load of the mill except for such times as were necessary to clean and overhaul the equipment. The low pressure process steam requirements were adequately met by extraction and exhaust steam and the larger generator satisfied the electrical demands with little difficulty. Operation of the 150 lb. plant to supplement the 1929, 400 lb. plant presented difficulties, and would have upset the balance between steam and electrical supply.

The mill process steam requirements have not changed to the same extent as the electrical load but both have increased materially and since it was deemed desirable to have two generating units and two high pressure boilers, plans were made early in 1937 to again enlarge the plant. So Frederick L. Smith, consulting engineer of New York, was retained to analyze the situation and as a result of his studies, a new high pressure boiler and turbine were added in the latter part of 1937. This installation was designed by and construction carried on under the supervision of Frederick L. Smith and has recently been placed in operation.

The essential features of the installation made in 1929 have been retained in the new. The new turbine is installed in the space formerly occupied by the 150 lb. turbine, space which really was reserved for another 2500 kv-a. unit. The new turbine, just installed, however, is of almost twice the capacity allowed for in 1929, being rated at 4375 kv-a. The new boiler also is of considerably greater steaming capacity. It is built for a working pressure of 450 lb. per sq. in., although it will be operated at practically the same pressure as the 1929 unit.

As shown by the plan in Fig. 1, the new boiler is installed in a new addition to the 1929 boiler house built on the site of the old 150 lb. boilers which have now all been scrapped.

While this new installation involves no strikingly new or unusual features it is of interest to know in what way, if any, the new installation just made differs from the one made in 1929. The installation of the new equipment was made under the difficulties that exist in the extension of almost any industrial power plant in that the existing equipment had to be kept in service while the new equipment was being installed. As always, space was limited, except in the new addition to the boiler house which is spacious, and close study of the existing piping was necessary to fit the new piping in place.

In general, the new addition is similar to the 1929 installation. In the boiler room the existing 10 in. main steam header was extended to connect with the new boiler and in the turbine room a new connection was made between the existing 400 lb. header and the new turbine.

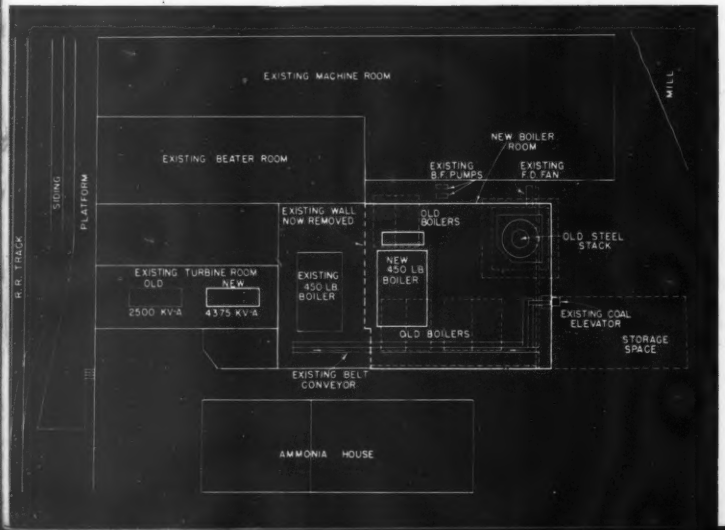


Fig. 1. Plan showing the boiler and turbine room with respect to the old boiler room

The principal difference in the arrangement of the new boiler as compared with the old is in the absence of the air preheater which permitted a change in the location of the forced draft fan.

The exhausts from both turbines are connected together into a header leading to the mill and which carries a pressure of 25 lb. Both turbines are bled at a pressure of 75 lb. and connected to another process steam line to the mill. This 75 lb. line is also connected to the main steam line through a reducing valve and desuperheater, and is in turn cross connected to the 25 lb. exhaust line through a reducing valve. Flow meters are installed at the points so that the amounts of various pressure steam to different points of use can be accurately measured. These are all Leeds and Northrup meters, recording on a 6 point automatic recorder. The desuperheaters are controlled by Swartwout thermal master controls.

As already mentioned, the new boiler is erected in a new extension to the boiler room and which has been built large enough to accommodate still another boiler unit should this prove necessary in the future.

The new boiler is a bent tube unit of 135,000 lb. per hr. capacity built by the Bigelow Co. and fired by a 9 retort link grate Westinghouse underfeed stoker. It is equipped with a convection type superheater and a steel tube economizer mounted at the rear of the boiler as shown. As in the case of the older boiler, the induced draft fan is located on the upper floor of the boiler but the forced draft fan in the case of the new unit is located in the basement. The change in location of the forced draft fan as compared with the old is due to the fact that in the case of the old boiler an air preheater was used. Since the air preheater was omitted in the new installation it was much more convenient to place the forced draft fan in the basement.

Consistent with modern practice, the furnace is water cooled. It is 16 ft. wide by 17 ft. 4 in. deep. The front water wall and arch has 32—3¼ in. tubes spaced 6 in. on centers, 22 ft. long, bare. The two side walls each have 8—3¼ in. tubes, 6 in. on centers, 18 ft. 9 in. long covered with cast iron blocks of the cast-on type. The rear wall has 32—3¼ in. tubes, 6 in. on centers, 17 ft. long, the lower part of which is covered with cast iron blocks of the cast-on type and the upper part with silicon carbide blocks.

The distribution of surface in the boiler is as follows:

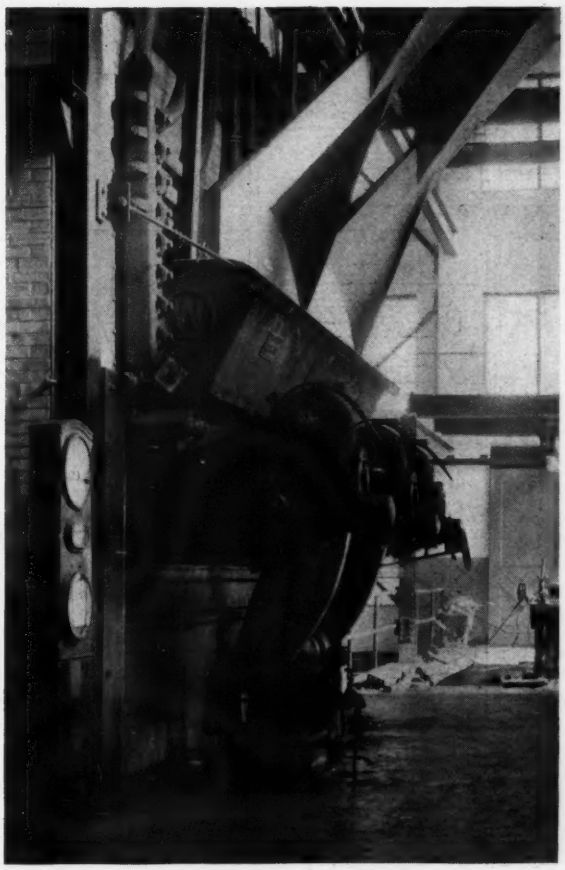


Fig. 2. A view of the new boiler

9800 sq. ft. in the boiler; 1500 sq. ft. in the superheater; 6000 sq. ft. in the furnace water walls and 8300 sq ft. in the economizer.

The economizer, which is a Foster Wheeler unit built for 450 lb. working pressure, consists of composite elements having seamless steel tubes covered with cast iron grilled rings shrunk upon them and arranged horizontally close to the gas outlet from the boiler. It is arranged for counterflow operation and is provided with soot blowers to keep the heating surface clean and assure high heat transfer in daily operation. The extended surface rings provide six times the heat-

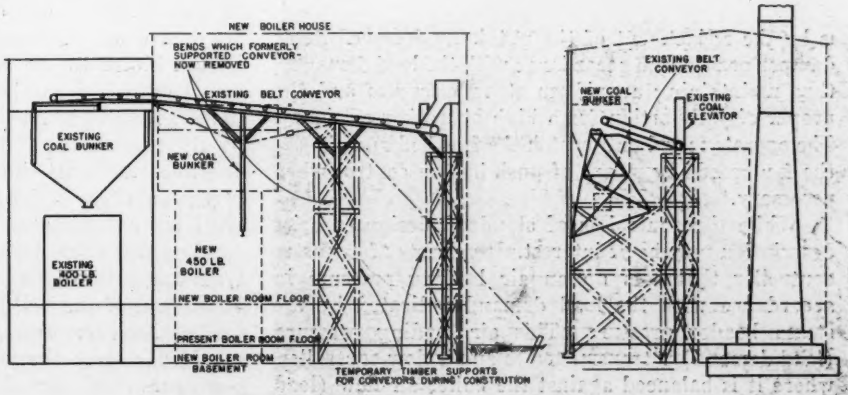


Fig. 3. Elevation, showing the constructional features involved in adapting the coal handling system for use with the new boiler

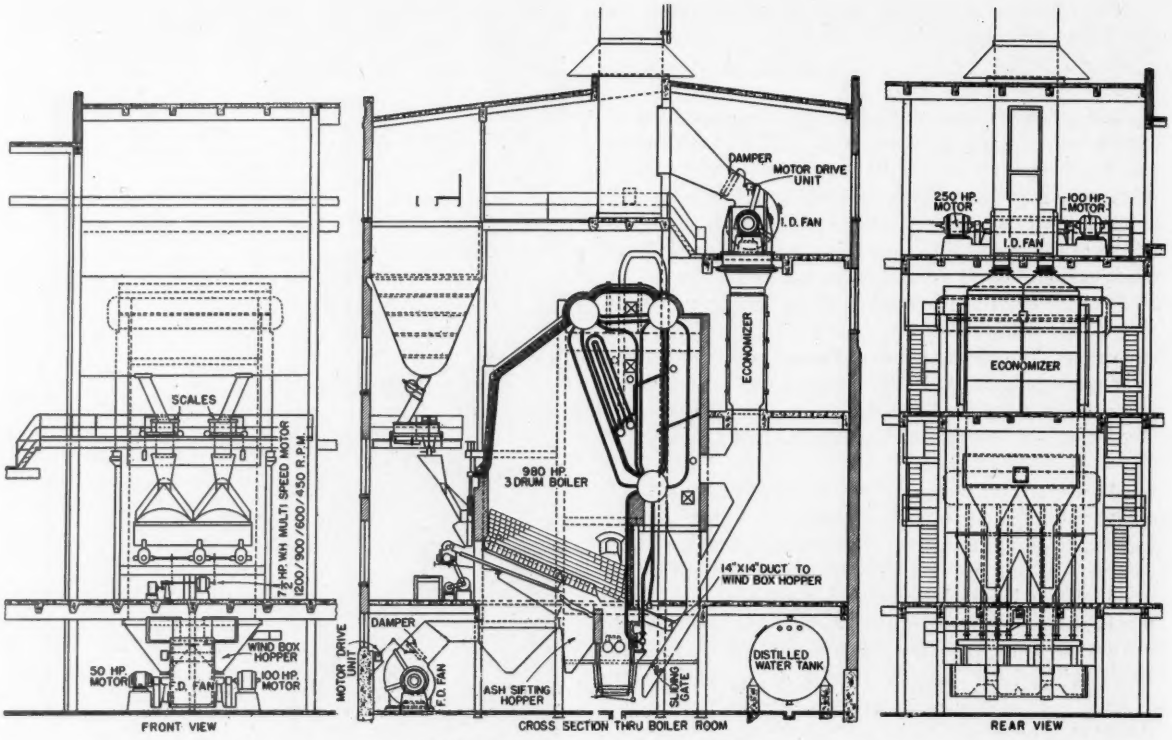


Fig. 4. Elevations of the new boiler unit

ing surface obtainable from bare tubes and this in turn gives such a compact economizer that it takes up scarcely more space than the ordinary flue.

Although the stokers are hand controlled, the boilers are controlled by a Leeds & Northrup "Metermax" system of combustion control working on the fan dampers. Automatic control of stoker speed was omitted, as there is probably as much variation in the quality of the coal as in the steam demands.

Both the forced and induced draft fans are driven by two squirrel cage motors, one 875 and one 1175 r.p.m., controlled manually by push button control from the control board according to damper position indicated differential draft readings across the damper and at the limits of travel by pilot lamps on the control board. Automatic speed control of the fans was not essential, since the fan speeds need be changed only rarely.

The entire automatic control, as already mentioned, is by the adjustment of the uptake and forced draft damper positions in accordance with the load demands, thus maintaining a uniform steam pressure and the proper air proportion for a high operating efficiency. The operator need only watch the fuel bed and change the fan speeds by means of push button control when necessary.

While the control is of standard design, a brief description may be of interest. It consists of a master controller that sets up an air loading pressure in accordance with the load demand indicated by the steam header pressure. This air loading pressure (load demand) is transmitted to an air flow controller, where it is balanced against the boiler air flow (load response) as measured by a differential draft drop across a section of the boiler. Any unbalance in these quantities therefore, causes an air flow controller unbalance, thus making a contact which readjusts the uptake damper through a motor driven unit. At the same time any change in furnace pressure unbalances the furnace pressure controller which similarly makes contact and readjusts the forced draft damper position through its motor drive unit. The control consists of three regulators, master, air flow and furnace pressure, all simple balances. The master regulator uses a Bourdon tube.

The master controller is a Bourdon tube actuated from the steam header pressure and controlling a combined leak off and bleed valve in an air supply line, thus setting up an air loading pressure corresponding to steam load requirements.

Until 1937 coal was delivered by truck to a bucket elevator with reciprocating feeder, elevated to a point above the roof of the old 150 lb. boiler room and delivered either to the old bunker or to inclined belt conveyors which carried the coal up to the bunker of the 400 lb. boiler. As these conveyors were supported by the roof of the 150 lb. boiler room, a temporary elevator was used during construction of the 1937 extension of the boiler room. Upon completion of the building, a horizontal flight conveyor was installed, running the whole length of the boiler room, and the temporary elevator moved to its permanent location at the end of the boiler room.

Provision for removal of ashes from the new boiler involved merely the extension of the existing drag conveyor which served the old boiler.

Principal Equipment in the Extension to the New Haven Pulp and Board Plant

General

Location	New Haven, Conn.
Owners	New Haven Pulp and Board Co.
Engineers	Frederick L. Smith, New York, N. Y.
Type Plant	Industrial—paper mill

Boiler Equipment

Boiler. 1 Bent tube, designed for 450 lb. w.p., 650 deg. T.T. 135,000 lb. per hr. max. with 9800 sq. ft. in the boiler, 1500 sq. ft. in superheater, 6000 sq. ft. in water walls and 8300 sq. ft. in economizer. The Bigelow Co.

Economizer. 1 Steel tube extended surface type. 8316 sq. ft. arranged in 22 rows of elements, 9 rows wide. Designed for 450 lb. w.p. Gas leaving economizer 425 deg. F. Feedwater to economizer 250 deg. F. The Foster Wheeler Co.

Stoker. 1 Underfeed, 9 retort, link grate, hydraulic drive, 4 speed motor drive. Westinghouse Electric & Mfg. Co.

Stoker Oil Pumps. Schutte & Koerting Co.

Coal Spreaders. Conical coal spreaders on stoker hoppers. Stock Engineering Co.

Forced Draft Fan. 1—55,000 c.f.m., at 70 deg. 7 in. S.P. driven by 2 squirrel cage motors, damper controlled. B. F. Sturtevant Co.

Induced Draft Fan. 1—104,000 c.f.m. at 425 deg., 7.8 in. S.P., driven by 2 squirrel cage motors, damper controlled. B. F. Sturtevant Co.

Forced and Induced Draft Fan Motors. General Electric Co.

Stack. Steel, 83 ft. high. Dover Boiler Works.

Boiler Accessories:

Feedwater regulator. Swartwout Co.
Soot Blowers. Diamond Power Specialty Corp.
Blow-off Valves. Yarnall-Waring Co.
Gage Columns. Reliance Gauge Column Co.

Coal and Ash Handling

Conveyor. Robinson Branin Co., New York.

Coal Scales. Automatic, electric. Richardson Scale Co.

Ash Hoppers. Allen-Sherman-Hoff.

Feedwater Heater and Pumps

Feedwater Heater. Deaerating type. Max. capacity 172,000 lb. per hr. Cochrane Corp.

Boiler Feed Pump. 1 new pump. 3 in. 5 stage centrifugal, 360 g.p.m., 1350 ft. head. Driven at 3600 r.p.m. by General Electric Co. wound rotor motor with 25 per cent speed reduction. Pennsylvania Pump & Compressor Co.

Booster Pump. 1 new pump. 125 g.p.m., 70 ft. head, 3450 r.p.m. Ingersoll-Rand Co.

Control and Instruments

Combustion Control System. "Metermax" combustion control operating the draft through damper adjustment. Consists of a master controller which is Bourdon tube actuated from main steam pressure, an air flow controller and a furnace pressure controller. Leeds and Northrup Co.

Pressure Gages. Hancock Valve Div. of Manning, Maxwell & Moore.

Depth Gage for Distilled Water Tanks. Pneumercator Co., Inc.

CO_2 Recorder. Ranarex. The Permutit Co.

Recorders on Steam Lines. Foxboro Co.; The Bristol Co.

Temperature Recorder. Leeds Northrup Co.

Desuperheat Control. The Swartwout Co.

General Equipment

Turbogenerator. 1—Non condensing, extraction turbine, designed for 400 lb., 650 deg., 80 lb. extraction and 30 lb. back pressure; direct connected to 4375 kv-a., 480 v., 5260 amp., 80 per cent p.f., 3 phase, 60 cycle, 3600 r.p.m. generator. Westinghouse Electric & Mfg. Co.

Miscellaneous

Vacuum Cleaner. United States Hoffman Machinery Corp.

Distilled Water Tank. Furnished by the Pneumercator Company, Inc., of New York City. Installed by the Owners.

Piping. Piping in general was shop welded and flange connected in the field, and was installed by Chas. M. Brown & Company of Phila., Pa.

Valves. Chapman and Edwards manufacture.

Traps. Crane manufacture.

Switchboards. Furnished by Westinghouse Electric & Mfg. Co. and their installation together with the wiring was done by the M. B. Foster Company of New Haven, Conn.

From the overhead coal bunker, the coal drops by gravity through two spouts to two Richardson automatic coal scales and then into the stoker hoppers.

Feedwater makeup is city water part of which is evaporated. The condensate from the evaporator is delivered into two distilled water tanks which also receives the overflow from the feedwater heater and the return from the traps. The evaporator is a Foster Wheeler unit of 7500 lb. per hr. capacity which was a part of the existing equipment. This evaporator furnishes about 2000 gal. of water per day.

From the distilled water tanks three booster pumps, two of which are old and one new, deliver the water to the deaerating feed water heater. The latter is a Cochrane unit, heated by exhaust steam from the 25 lb. header and receiving the returns from the paper machines. The feedwater feeds a header which supplies three feed pumps, one of which is a new unit, a 3 in. 5 stage motor driven centrifugal. A feedwater temperature of about 250 deg. is maintained.

Conclusion

The completion of this installation provides the New Haven Pulp and Board Co. with a thoroughly modern plant—a plant capable of meeting every steam and power requirement reliably and efficiently. The new boiler has not been in operation long enough to present final figures but an overall efficiency of 86 per cent has been attained at various times. The coal used varies considerably in quality but on the average runs about 14,700 B.t.u. per lb. dry, with 17.7 per cent volatile and 5.3 per cent ash. As in our earlier description of this plant, it is still operated under the capable supervision of H. D. Fisher, the plant engineer, to whom we are indebted for many courtesies and assistance in gathering data for this article.

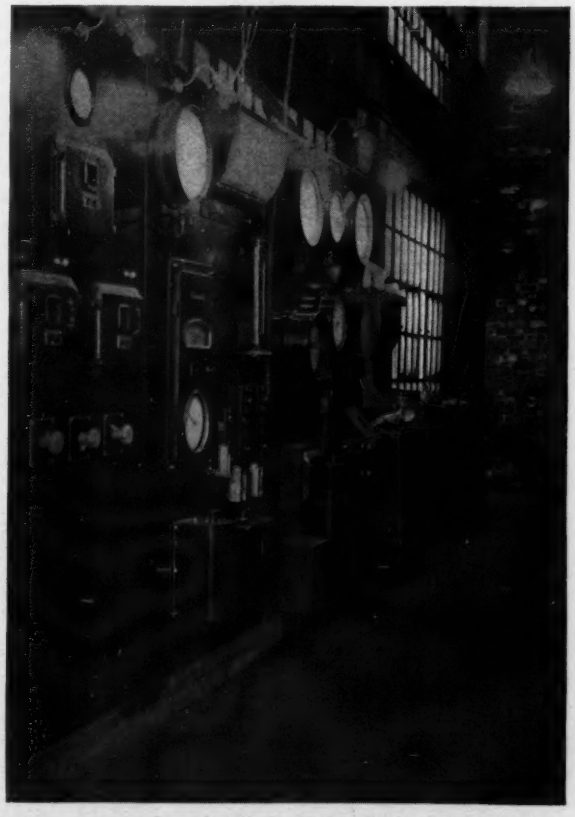


Fig. 5. The main boiler control board

Burning Indiana Coal on Industrial Stokers

An abstract of a paper presented before The Indiana Coal Conference held at Purdue University, April 28.

By L. F. LANG

Detroit Stoker Co.
Chicago, Ill.

ALTHOUGH MANY of the engineering principles as used in the design of the large central station also apply to the moderate sized industrial plant, it is the intention of this paper to discuss the design and application of mechanical coal burning equipment to the plant under 500 hp.

In addition to the primitive hand fired grate, Indiana coal is being burned on overfeed stokers, chain grates, underfeed and spreader type stokers, all with a varying degree of success. The question is immediately asked, which type of stoker is the best? The answer to that question is determined by the characteristics of the plant itself, the physical conditions, service required and load to be carried. There is no one best stoker, but there is one type better suited to a set of conditions than a stoker of another type. When reference is made to, or when one type of stoker is compared to another, it has no reference to any particular make or manufacture of stoker, consideration being given to type only, such as an overfeed, underfeed, chain grate or spreader.

The job of selecting the proper type of stoker is simplified to a great extent by the fact that there is a definite field best suited for each type of stoker.

For the small industrial low pressure heating plant using the steel firebox type of boiler, the single retort underfeed stoker is definitely recommended. On larger heating installations the inclined grate natural draft and the industrial type single retort stokers are most generally used.

The field begins to broaden from 150 to 300 hp. Here we also have the single retort underfeed and the inclined grate overfeed. At this point the chain grate and spreader stokers begin to make their appearance.

From 300 up to 500 hp. we find the chain grate, the double retort and triple retort underfeed side dump stoker, the multiple retort rear dump stoker and the spreader type stoker to choose from.

Indiana coal being that of low B.t.u., high ash content and comparatively low melting point of ash requires (1) ample draft, (2) generous grate areas, and (3) a properly designed furnace to burn it successfully.

Draft

By ample draft we mean at least 0.1 in. to 0.15 in. available in the furnace for the maximum boiler rating in the case of any forced draft stoker and from 0.3 in. to 0.35 in. for natural draft stokers. These drafts are necessary in order to prevent any "bottling" effect of the furnace gases which tend to produce high furnace temperatures. Indiana coal should not be subjected to high furnace temperatures because of its low melting point of ash.

Any stoker using natural draft requires the higher draft because the stack not only carries the products of combustion through the heating surface of the boiler but also pulls the air for combustion through the fuel bed, whereas, with stokers using a controlled draft fan for furnishing the air for combustion, it is only necessary for the stack to draw the products of combustion through the boiler.

Grate Area

The capacity limitation of the underfeed and overfeed stoker being that of clinker formation, large grate areas are needed so as to reduce the coal burning rate per square foot of grate and, at the same time, provide for the accumulation of the ash and clinker produced. A coal burning rate of about 30 lb. per sq. ft. of grate area is recommended for underfeed stokers, although the most successful jobs using Indiana coal are where the coal burning rate is considerably less. While burning rates of over 100 lb. of Fifth Vein Indiana coal per sq. ft. have been reached with spreader stokers, the accepted practice is between 30 and 50 lb. per sq. ft. of grate area for continuous operation.

Furnace Design

Large furnace volume is desirable to provide ample space between the grate and the heating surface of the boiler to complete combustion within the furnace. In addition to a large furnace volume, ample boiler heating surface exposed to the furnace is essential in order to keep down the temperature of the furnace, which will not only reduce clinker formation but will also reduce brickwork maintenance. In a well designed furnace, between 30 and 40 per cent of the total exposed surface should be heat absorbing, or what is commonly known as black surface. A heat release of 45,000 B.t.u. per cu. ft. of furnace volume is well within reason for underfeed stokers and 30,000 B.t.u. for the spreader type.

The underfeed stoker will stand a higher heat release due primarily to the fact that all of the coal is burned on the grate and in the center of the furnace with very little burning taking place on the dead plates or dump plates at the sides of the furnace. The

underfeed stoker does not require mixing of gases above the grate and produces a short flame. Any stoker that relies on mixing the products of combustion above the grate requires about 50 per cent more furnace volume than an underfeed in order to get complete combustion within the furnace, the extreme case being that of pulverized fuel, where all of the coal is burned in suspension.

Next to pulverized fuel the spreader type stoker requires the largest furnace volume. With this type of stoker only the fine particles are burned in suspension and the coarser coal is burned on the grate. The overfeed and chain grate stokers distill the gases from the fuel on the grate and rely on ignition or mixing arches above the grate to complete their combustion. Thus the overfeed, chain grate and spreader type stokers are long flame burners.

Load Characteristics

The natural draft chain grate is slow to respond to a sudden change in load and, as a result, its application is best suited to plants where the steaming rate of the boiler does not vary over long periods of time. The forced draft chain grate is quicker to respond to a change in load than the natural draft type. The underfeed and the spreader type stokers are very responsive to sudden variations in load conditions.

The spreader stoker in particular is extremely flexible due to the fact that there is practically no time lost between the change in load and corresponding change in fuel and air supply. The amount of fuel carried on the grate is so small that if the coal feed is stopped the fuel on the grate can be completely burned in a few minutes. The burning zone of the fuel bed is only 1 to 2½ in. thick. Numerous air streams penetrating the fuel bed have a cooling effect on the ash underneath the fire, thus preventing the formation of clinker. For extremely light loads the spreader stoker can be operated on natural draft, or, depending on the number of feeders, one or more with its air supply can be shut off and only a portion of the grate kept in operation, thereby maintaining a coal burning rate per square foot of grate area that more nearly approaches standard practice.

Conclusion

In the large central station the selection of coal burning equipment is not nearly as difficult a task as it is in the moderate sized industrial plant under consideration due primarily to the fact that in the large plant one type of boiler is used, namely, the water tube, whereas in the smaller plants a greater variety of boilers will be found including low pressure firebox, horizontal return tubular and two drum fire tube, as well as the water tube boiler. The type of boiler to be stokered is naturally the first consideration. The success of the combined unit will vary directly with the practical combination of the boiler and stoker. In other words, the practicability of the combination of boiler and stoker is the factor that will determine its success or failure. The job, then, is to select equipment of established performance and an intelligent application of that equipment.

Measuring Ten Millionths of An Inch

AFTER a rainy day the puddles in a city street are often covered with surface films of oil, which reflect bright patches and streaks of color. A streak of oil seven millionths of an inch thick has a straw-yellow color, while a streak nine millionths of an inch thick appears red. The colored areas thus constitute an accurate contour map of the "topography" of the oil film, the scale of contour levels from one color to the next being one or two millionths of an inch.

The colors reflected by transparent films having thicknesses less than 0.00005 in., called "interference" colors, have been understood since the days of Isaac Newton. However until 1934 no method was known of building standard films of known thickness which could be used as color gages for measuring films of unknown thickness.

A method which was devised in the Research Laboratory employs sheets of barium stearate which have a uniform thickness of 0.0000001 in. Each sheet consists of a single layer of molecules of barium stearate. The layer is prepared by placing a small amount of stearic acid on water containing a barium salt. The individual molecules of which stearic acid is composed endeavor to attach themselves to the water surface, with the result that the stearic acid spreads out over the water until each molecule has a place on the surface. The molecular layers are transferred to a metal surface by a dipping process at a rate of about 20 layers per min.

Color gauges are made by building on a polished chromium plate a series of steps having 21, 41, 61, 81, and up to 201 layers of barium stearate. These steps have thicknesses of 2, 4, 6, 8 millionths of an inch, which is the range of thickness in which films reflect most vivid interference colors. Films of other substances such as iron oxides, showing interference colors, are measured by comparing the color of the oxide with the colors of the steps of the gage.

In certain ranges of color series the eye can easily detect differences of thickness of 0.0000001 in. By means of suitable optical apparatus differences of 0.00000001 in. are measured. This means that single molecular layers of many substances which are of utmost interest to the biologist, chemist, or physicist can be measured quantitatively by the color change which a single layer causes when deposited on top of a barium-stearate film.—Dr. Katharine Blodgett, G-E Research Laboratory.

Total installed capacity of water wheels in water-power plants of 100 hp. or more in the United States was 17,284,379 on January 1, 1938, states the Federal Power Commission. This capacity is installed in a total of 2840 plants, 1537 of which are operated by privately or publicly owned electric utilities and 1303 by industrial and other concerns. Increases in installed capacity since January 1, 1933, have been relatively slight except that 1,040,203 hp. was installed during 1936.

Distribution of installed capacity in percentages by regions is: New England, 11.6; Middle Atlantic, 14.1; East North Central, 7.2; West North Central, 4.9; South Atlantic, 18.6; East South Central, 9.0; West South Central, 0.9; Mountain, 10.2; Pacific, 23.5.

MODERN UTILITY

IV—The Associated Gas & Electric System

By JAMES A. POWELL

Vice President
E. M. Gilbert Eng. Corp.
Reading, Pennsylvania

ELECTRIC OPERATING COMPANIES comprising the Associated Gas & Electric System serve areas in 27 states and include a total generating capacity of 1,474,685 kw. This capacity is distributed among 207 plants including hydro, Diesel and fuel burning stations. The latter classification includes 137 plants; 65, with a total installed capacity of 1,013,241 kw. burn coal; one, with a capacity of 53,000 kw. burns oil and gas; and 71 with a total capacity of 56,497 kw. burn gas and oil.

Since 1932 there have been installed, or proposed for extensions to old plants or construction of new plants, ten steam plants, with a total capacity of 121,500 kw. and eleven Diesel plants with a total capacity of 5206 kw. of which only two units are 1000 kw. or over. Principal data on the steam plants are given in Table I. Additions to the boiler plants consist of 14 units ranging in size from 100 hp. to 250,000 lb. of steam per hr. and in pressure from heating boilers to 1400 lb., 900 deg. F.

Engineering work was handled by the E. M. Gilbert Engineering Corp., and although none of these plants involve units of unusual size nor any major radical steps in power plant design, there is installed in each plant the most modern equipment and the policy of the company has been to encourage new ideas. Many features of the plants have necessitated joint development work between the engineers of the manufacturers and the plant designers. Some of these developments include:

- First use of the bubble type of steam washer at No. 3 Station of the Rochester Gas & Electric Corp., Rochester, N. Y.
- Installation of 725 lb., 750 deg. F. boiler equipment with 650 lb. topping turbines and 100 per cent boiler makeup at No. 3 Station of the Rochester Gas & Electric Corp., Rochester, N. Y.
- Installation of low head dual type furnace boilers at the West End Station of the Keystone Public Service Co.
- Installation of a simplified backwashing system for surface condensers as installed in Dresden Station and in No. 3 Station at Rochester.
- Installation of a superheater blow system to reclaim steam loss and eliminate noise in starting up the boiler unit in the Dresden Station of the New York State Electric & Gas Corporation.
- Installation of water-cooled underfeed stokers at the Seward, Pa., Plant of the Pennsylvania Electric Co.

Construction of the new plants and modernization of the old plants have been of such a varied nature that no standard program could be followed. However, the company is extremely interested in urging standardization of manufacture and design consistent with progressive development between the design engineers and the manufacturers to bring about the construction of economical plants with a minimum investment to provide electrical energy at the switchboard at a minimum combined fixed charge and operating cost.

Dresden Station[1]

Increased demand on the power system of the New York State Electric & Gas Corp., called for the installation of new generating equipment. While existing plants in this system could have been extended, it was considered desirable to build a new plant as the

Fig. 1. Interior of Dresden Station, showing the station arrangement and the absence of curtain walls between the boiler room and turbine room. The initial installation consists of two 700 lb., 825 deg. F., 110,000 lb. per hr. boilers and one 20,000 kw. turbine. The ultimate capacity of the station is 90,000 kw.

[1]For a more complete description of this station see the article Dresden Station beginning on page 358 of the June 1938 issue of Power Plant Engineering.

STATIONS

IV. The Associated Gas & Electric System. With operating units in 27 states, the Associated Gas & Electric System extends over the southeastern half of the United States in the triangular shaped area formed by the three states of Maine, Arizona and Florida. The engineering policy has always been progressive and Gilbert Station was one of the pioneer 1200 lb. reheat stations that made power plant history in the pre-depression era. With one exception, the present program is confined to the moderate pressure, high temperature range because, for the specific conditions encountered, this gives, at the present time, the most economical distribution of operating and capital charges. Engineering work on the system has been for many years under the direction of the E. M. Gilbert Engineering Corp. of Reading, Pa.

first step and leave the extension of other plants for future consideration. The site selected, on the shore of Seneca Lake, provides cool condensing water and good railroad facilities. This plant was projected for an ultimate capacity of 90,000 kw. in three units. The first unit installed has a capacity of 20,000 kw. to meet present conditions, but provision for future units of 35,000 kw. has been made. Because this was the first unit in the new plant, it was thought advisable to install two boilers, so that if trouble developed with one boiler, the plant would not be completely shut down. The wisdom of this decision has been borne out already by trouble which developed on one of the pulverizer gears and which took about a month to remedy. During this period the plant operated at half capacity.

Construction of the plant was started in April, 1937, and the plant was put in operation March 15, 1938. The design is such that the turbine and boilers are in a single room, with a centralized control for the plant located between the boilers and turbine.

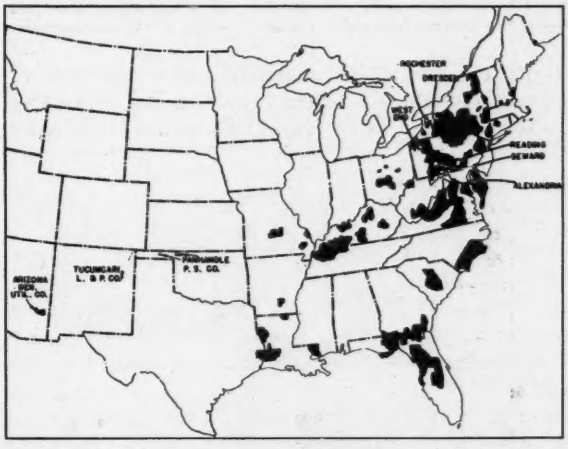


Fig. 2. Operating companies of the Associated Gas & Electric System serve areas in 27 states. Locations of the stations mentioned in Table I are indicated

Heat Rate 11,966

Each of the two 700 lb., 825 deg. F. Foster Wheeler boilers has a capacity of 110,000 lb. per hr. They are of standard three drum design with convection superheaters and water cooled furnace walls. The superheater bypass is arranged with a motor-operated butterfly valve to bypass the gas leaving the boiler for temperature control purposes. This valve is regulated by push buttons on the boiler board. Both economizer and air heaters are used and dust eliminators have been installed. Each unit is fired by one Hardinge pulverizer through two 20 in. burners, and both boilers are controlled by General Regulator Co. combustion control. At full load, the designed heat rate of the station is 11,966 B.t.u. per net kw-hr.

The 20,000 kw. General Electric turbine drives a 13,200 v., 3 ph., 60 cycle, 3600 r.p.m. generator with a 250 v. exciter and pilot exciter. This turbine is set over a 16,860 sq. ft. Westinghouse, 2 pass, divided water box condenser with two vertical propeller type circulating water pumps installed, each pump serving half the condenser. A unique feature of the design are two elbow reversing valves which is shown on the left of Fig. 7.

Generator leads are connected to a general bus on an outdoor steel transformer structure through an oil circuit breaker. A bank of four 8333 kv-a. power transformers are connected to the general bus through oil circuit breakers. These transformers are of the multiwinding type, 13,200/33,000-66,000-114,000. Provision has been made to install 33 and 66 kv. circuits later. At present the 114 kv. windings are connected through disconnecting switches to the main and inspection buses on a 114 kv. switching structure, located approximately 1000 ft. from the station.

Station service and lighting is taken care of by a bank of 1250 kv-a., 13,200/2300 v. transformers; three 200 kv-a., 2300/230-115 v. transformers, and one 75 kv-a., 2300/230-150 v. transformer. These are located in the outdoor transformer structure. The 1250 kv-a. transformers are tapped directly off the general bus through disconnecting switches. Another bank of three 50 kv-a., 2300/230-150 v. transformers serves the coal handling equipment.

In addition to the simplified system of backwashing, shown by Fig. 7, the most novel feature of the

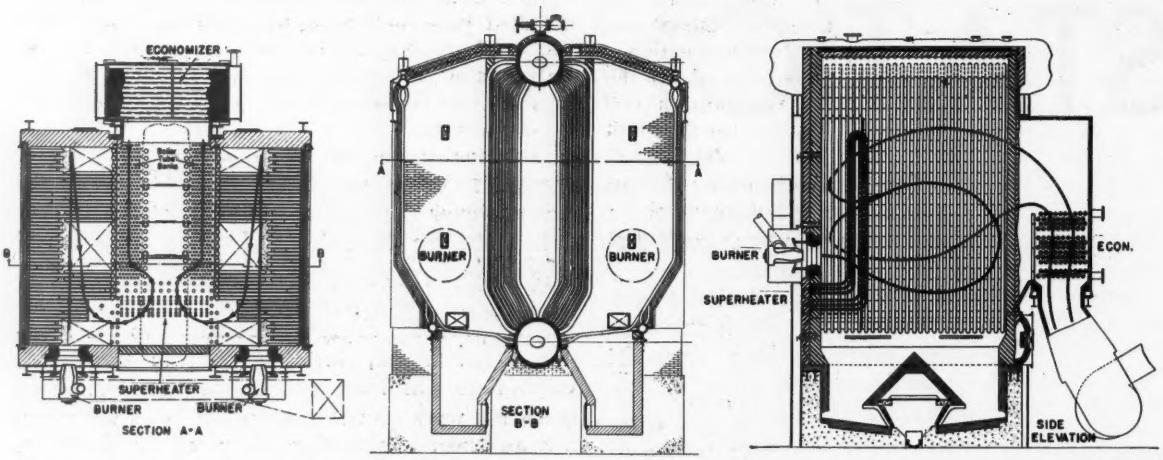


Fig. 3. At the West End Station of the Keystone Public Service Co., a Foster Wheeler boiler of unusual design has been installed. This is a 675 lb., 600 deg. F. unit consisting of a two drum, bent tube boiler, two independent water cooled furnaces, a single superheater and an economizer. It is fired by pulverized coal and, together with a 5000 kw. turbine, constitutes an addition to an existing plant. The boiler is now operated at 200 lb. but will be increased to full design pressure when the contemplated top turbine is installed

station consists of the installation of a new type of superheater blow to reclaim the steam loss in starting up the boiler so as to reduce the makeup, condense the steam and eliminate noise during the starting-up period.

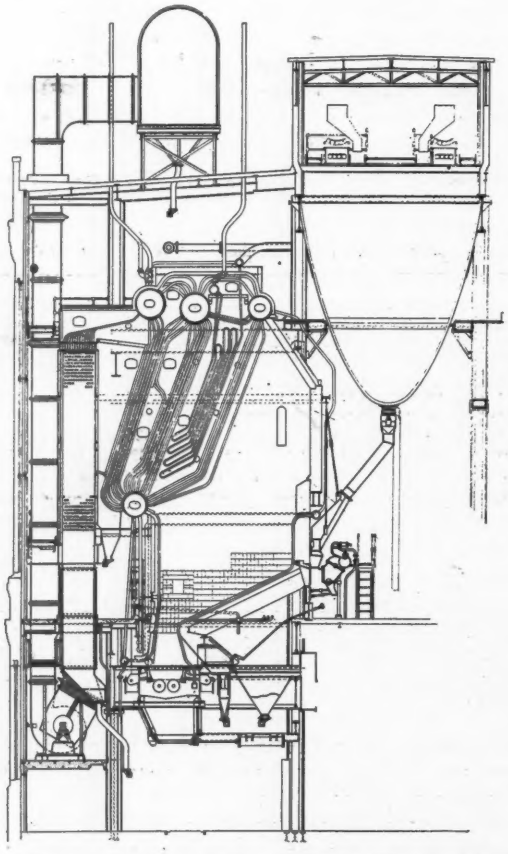


Fig. 4. Cross-section of one of the two 725 lb., 825 deg. F. Seward boilers, each with a capacity of 200,000 lb. per hr. These Babcock & Wilcox units are fired by Taylor water-cooled underfeed stokers and were installed in space originally provided for 100,000 lb. per hr. boilers. At present these boilers feed into the existing 275 lb. system through a Hagan Corp. reducing valve and desuperheater station. Eventually a building addition will house a 35,000 kw. hydrogen cooled turbo-generator

West Reading Plant

The West Reading Plant of the Metropolitan Edison Co. is located on the Schuylkill River at Reading, Penna., close to the load center of the Metropolitan Edison system. When the present rehabilitation and expansion was proposed, there was 69,000 kw. of turbine generator capacity installed in this plant. Two 4500 kw., one 10,000 kw., and one 20,000 kw. unit, all designed for operation at 190 lb. ga., 500 deg. F., total temperature steam at the throttle, were connected to jet condensers. A 30,000 kw. turbo unit operating at 250 lb. ga., 600 deg. F. total temperature exhausts into a surface condenser. The 200 lb. steam is supplied by four boilers of 24,000, and two boilers of 70,000 lb. per hr. each, and the 265 lb. steam is supplied by six boilers of 70,000 to 85,000 lb. per hr. each. The dependable output of the plant was limited to 45,000 kw. by the boiler capacity. The general plan of station expansion is divided in two steps to be carried out in the following order:

1. (a) Renozzling of the turbine of the 20,000 kw. unit to increase the capacity from 20,000 to 25,000 kw., and to permit use of 250 lb. ga. pressure steam paralleling the pressure and temperature used on the 30,000 kw. unit. The generator of this unit had previously been rewound for the higher capacity. (b) Replacement of the jet condenser with a 2 pass surface condenser with auxiliaries. (c) Installation of a bleeder heater to improve the heat balance of the unit. All of this work has been completed and was put in service in February of this year.

2. For future additional capacity, it is contemplated to install two new 1400 lb. pressure boilers of 275,000 lb. capacity each, and a 20,000 kw. topping turbine generator unit operating at 1250 lb. ga. and 900 deg. F. total temperature at the throttle and exhausting at 265 lb. ga. to the 25,000 kw., and the 30,000 kw. turbine generators. The two new boilers and the topping turbine with auxiliaries will be housed in a new building adjacent to the existing plant.

The output of the two 1400 lb. pressure boilers will furnish sufficient steam, through the new 20,000 kw. topping turbine unit, to generate 43,500 kw. with the existing No. 5 and No. 6 units. In order to obtain the maximum combined output of these two units (55,000 kw.), approximately 172,000 lb. of steam per hour will be required from the existing 265 lb., 600 deg. F. boilers. The remaining old boilers will have sufficient steaming capacity to provide the steam required for the full rated output of the other turbine generator units.

Selection of steam of 1400 lbs., 900 deg. F. was based on a desire to obtain maximum available capacity in the topping unit, together with the fact that the use of surface condensers and evaporators allowed operation with a minimum amount of makeup, without any limitation in pressure, as in the case of the Rochester plant, where 100 per cent makeup is used.

Due to the falling off of the load, the installation of the two 275,000 lb. per hr., 1400 lb. boilers, and the 20,000 kw. topping unit has been temporarily deferred. Upon the completion of the expansion program, as discussed above, the West Reading Station will have a rated capacity of 94,000 kw.

Rochester Gas & Electric Corp. System

The Rochester Gas & Electric Corp. has obtained its power supply mainly from its hydro and steam plants, though some hydro power has been purchased. The hydro plants have an installed capacity of 45,000 kw., but due to the fact that the capacity is governed by stream flow, only 17,000 kw. of firm hydro capacity is obtained. The steam power plants, prior to 1935, consisted of Station No. 3, with a total capacity of 65,000 kw., and smaller steam plant primarily used for heating and process steam with 3000 kw. capacity. Studies indicated that additional capacity required could most economically be obtained by rehabilitating Station No. 3, because of its close proximity to the load center, and the necessity of replacing old boiler equipment in this plant. Since new boilers had to be installed, these could be made for high pressure, which would give additional turbine capacity through installation of topping turbines, allowing the old turbine units to be operated with exhaust steam at 200 lb., 525 deg. F.

Existing turbine units were all provided with jet condensers, and it was found difficult and uneconomical to change these to surface condensers. Accordingly, the problem was to install a new feedwater treatment system which would permit high pressure boilers to be operated with 100 per cent makeup, without excessive cleaning of boilers, and, with a minimum of scale deposit in boilers and turbines. The fact that 100 per cent makeup had to be used, made it advisable to limit the high pressure boilers to 700 lb. pressure. With the initial pressure of 650 lb. at the turbine, and an exhaust temperature of 530 deg. F. at 200 lb., the initial temperature was set accordingly at 750 deg. F. With these steam conditions, a 6000 kw. topping turbine was intalled to cover the immediate demand for the 1935 extension. A 250,000 lb. per hr. Combustion Engineering boiler, with pulverized fuel firing and two ball type unit mills were installed, together with economizer, steam air preheater and electric dust precipator.[2] This equipment was installed in a new building extension, the turbine room being designed to house a second identical unit in the future.

The use of a single boiler and turbine requiring minimum outage of equipment imposed a critical set of conditions with respect to both feedwater treatment and steam purification. It was necessary that the feedwater be absolutely non-scale-forming, and that carryover to the superheater and turbine be limited to the lowest possible point.

Raw water for the station is obtained from the Genesee River. This is a surface water stream, the chemical composition of which varies greatly at different seasons of the year, and, in addition, is fairly heavily contaminated with domestic and industrial

Table I. Principal data on several of the larger steam plants recently constructed, now under construction or proposed for the Associated Gas & Electric System. Two of these stations include air heaters, Dresden 10,560 sq. ft. tubular and West Reading 40,400 sq. ft. regenerative units

OPERATING CO.	STATION	LOCATION	TYPE OF PLANT	INITIAL OPERATION	THROTTLE PRES. lb./sq.	THROTTLE TEMP. °F.	BOILERS NO.	BOILERS CAPACITY lb./hr. each	BOILERS BOILER sq. ft.	BOILERS SUPERHEATER sq. ft.	BOILERS SUPERHEATER T. CONTROL	BOILERS ECON. sq. ft.	BOILERS FLY-ASH COLLECTOR	BOILERS W. W. sq. ft.
N.Y.S. Elec. & Gas Corp.	Dresden	Dresden, N.Y.	New Plant	1937	725	825	2	110,000	9750	2510	Bypass	2300	Cyclone	2719
Rochester Gas & Elec. Co.	Station No. 3	Rochester, N.Y.	Addition	1935	650	750	1	250,000	15,300	4450	——	20,800	COT	3990
Rochester Gas & Elec. Co.	Station No. 3	Rochester, N.Y.	Addition	1937	650	750	1	250,000	15,300	4450	——	20,800	COT	3990
Rochester Gas & Elec. Co.	Station No. 3	Rochester, N.Y.	Addition	1938	650	750	1	250,000	15,300	4450	——	20,800	COT	3990
Penna. Electric Co.	Seward	Seward, Pa.	Addition	1937	650	825	2	200,000	16,320	5820	——	9320	——	1407
Keystone Pub. Serv. Co.	West End	Oil City, Pa.	Addition	1936	650	750	1	100,000	10,800	1000	——	3980	——	——
Virginia Pub. Serv. Co.	Alexandria	Alexandria, W. Va.	Addition	1936	725	750	1	60,000	6450	1200	——	4930	COT	580
Metropolitan Edison Co.	West Reading	Reading, Pa.	Addition		1400	900	2	275,000	9100	7300	Bypass	8400	COT	9400

STATION	FURNACES VOL. cu. ft.	FURNACES H.REL'S. B.T.U./cu. ft.	FURNACES TYPE BOT.	FURNACES TYPE FIRING	AUXILIARIES F.D. FANS No.	F.D. FANS C.F.M. each	F.D. FANS in H_2O	F.D. FANS °F.	AUXILIARIES I.D. FANS No.	I.D. FANS C.F.M. each	I.D. FANS in H_2O	I.D. FANS °F.	AUXILIARIES B.F. PUMPS No.	B.F. PUMPS G.P.M. each	GENERATING UNITS No.	RATING kw.	SPEED R.P.M.	B. PRES. lb./sq. in. abs.	COND'SR sq. ft.	GEN. COOL
Dresden	5570	20,400	Dry	P. C.	1	32,900	7.5	100	1	59,000	11.5	385	2	525	1	20,000	3600	0.50	16,950	Air
Station No. 3	13,700	20,000	Dry	P. C.	1	69,000	4.5	80	1	140,000	7.7	340	2	750	1	6000	3600	225.0	——	Air
Station No. 3	13,700	20,000	Dry	P. C.	1	69,000	4.5	80	1	140,000	7.7	340	2	750	1	6000	3600	225.0	——	Air
Station No. 3	13,700	20,000	Dry	P. C.	1	69,000	4.5	80	1	140,000	7.7	340	2		1	25,000	3600	0.615	20,500	Hyd.
Seward	9300	30,300	——	W.C. Stok.	——	Exist. Fans	6.0	80	2	64,800	9.0	375	2	900	1	35,000	3600	0.615	29,300	Hyd.
West End	6280	21,500	Dry	P. C.	1	31,300	9.0	——	1	62,500	6.6	——	1-1	350-500	1	8000	3600	0.615	28,000	Air
Alexandria	2100	41,000	——	Stoker	1	24,000	——	——	1	38,600	5.25	353	2	187	1	5000	3600	0.74	4900	Air
West Reading	15,700	23,400	Dry	P. C.	2	55,000	9.0	100	2	93,000	12.75	370	3	680	1	20,000	3600	225.0	——	Air

[2]For a detailed discussion of this phase of the program see the article New Top for Rochester beginning on page 206 of the April 1938 issue of Power Plant Engineering.

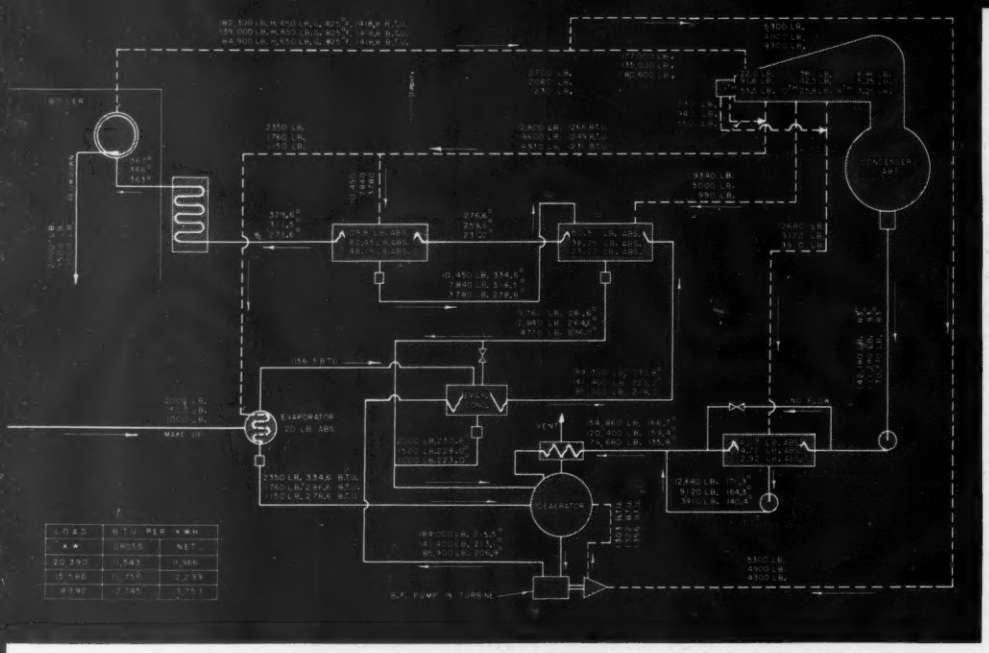


Fig. 5. Heat balance of Dresden plant, a completely new station which at a full load of 20,390 kw., has a calculated heat rate of 11,943 B.t.u. per gross kw-hr., or 11,966 B.t.u. per net kw-hr.

wastes. The feedwater purification system installed to cope with this severe water condition consists of double softening, first by lime and soda, and then by phosphate in a hot process softener, to complete the removal of hardness. The softened water is finally filtered through a non-siliceous filter medium. Double deaeration is effected; first, in the reaction tank of the phosphate softener, and again in the storage compartment of this tank from which the softened water is discharged to the filters. A secondary dose of phosphate is applied directly to the boiler drums.

Operation of the system to date has demonstrated that this system of feedwater treatment is satisfactory, and that scale formation in the boiler can be compleely inhibited, and corrosion of the economizer, boiler and superheater entirely prevented.

Besides the feedwater treatment, the outstanding feature of the 1935 extension, was the use of a new bubble type steam washer,[8] located in the rear drum of the Combustion boilers, designed on the principle of scrubbing the contaminated saturated steam with incoming feedwater, prior to delivery of the steam to the superheater. With this type of washer, it has been found possible to carry solids in excess of 3000 p.p.m. in the drum, with less than 1 p.p.m. solids in the steam leaving the boiler.

[8]The general arrangement of this steam washer is shown on page 317 of the May 1937 issue of Power Plant Engineering.

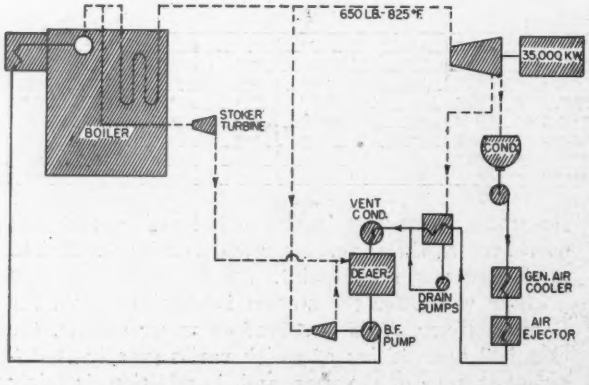


Fig. 6. Flow diagram of Seward Plant of the Pennsylvania Electric Co. Two boilers, Fig. 4, fired by water-cooled stokers are already installed. Eventually a 35,000 kw. hydrogen cooled turbo-generator will be installed in a new addition. This is a mine mouth plant and the low fuel cost does not justify a more elaborate feed heating cycle

1936 Extension, Rochester

In 1936, after the first boiler and turbine had been in operation long enough to indicate that successful operation could be obtained with 100 per cent makeup, it was decided to install a second boiler and a second turbine of identical design. An old 7500 kw. house turbine was replaced by a new unit operating at 200 lb. ga., 525 deg. F., with a surface condenser. This surface condenser is used for partially preheating feed water and is a combination two and four pass condenser. Sufficient water from the discharge of the condensers is used as makeup in pre-treating tanks prior to the delivery to the hot process feed water system. This arrangement has reduced the amount of chemicals required, due to the increased temperature of water, and improved the economy of the treatment.

1937 Extension, Rochester

The two 6000 kw. topping turbines, each with a 250,000 lb. per hr. boiler, supply sufficient steam for the existing low pressure turbines and steam send out, and the next step in turbine capacity called for a condensing unit. This is a 25,000 kw., 3600 r.p.m. unit of the welded hood construction with a hydrogen cooled generator and a surface condenser. In order to have the boilers interchangeable, this turbine was designed to operate at the same steam conditions as the two—6000 kw. topping turbines, and, a third 250,000 lb. per hr. boiler was installed. The three boilers operate on a common main which supplies steam to the two 6000 kw. topping turbines, and, a third 250,000 densing turbine. The condensate from the 25,000 kw. turbine and the 7500 kw. turbine discharge into a common mixing chamber with the treated makeup water.

The program provides for a total capacity at Station No. 3 of 102,000 kw., with a fourth 250,000 lb.

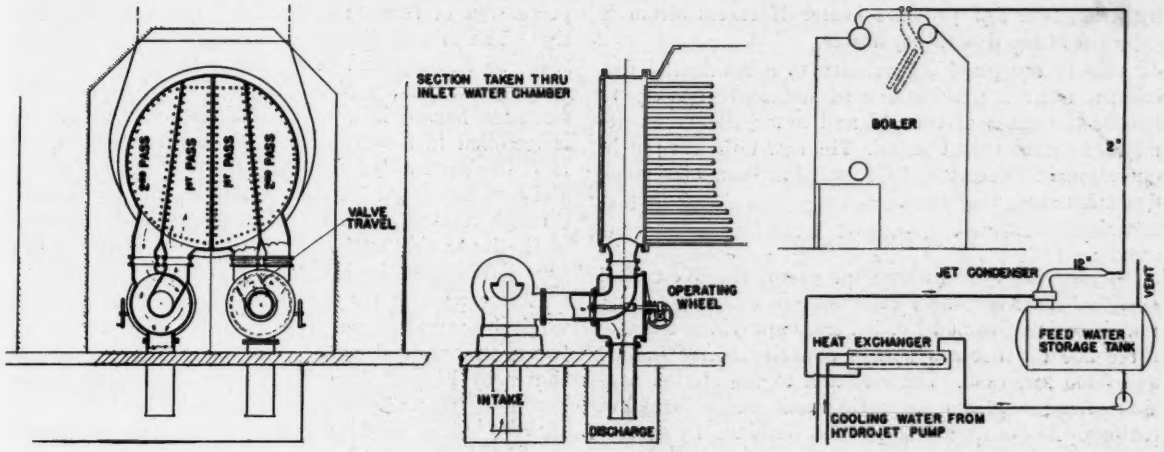


Fig. 7. The two drawings on the left show the special valves used for back washing the condenser, and which replace 8 valves used in the conventional arrangement. At the right is a diagrammatic arrangement of the superheater blow system used at Dresden for reclaiming condensate during the starting-up period. Steam is led to a jet condenser on top of the 15,000 gal. boiler feed storage tank in the basement. A recirculating pump, under the boiler feed pump, pumps the stored water through the heat exchanger into the jet condenser head for condensing the steam

per hr. boiler to be installed as a spare for one of the other three boilers within a year or two. This will complete the extension at Station No. 3.

Extension to Alexandria Plant

When, in 1935, additional capacity was required at the northern end of the power system of the Virginia Public Service Co., it was decided to install an additional unit in an extension to an existing steam power plant in Alexandria, Va. Apart from a separate eastern section with a steam plant at Hampton with 27,000 kw. installed capacity, the interconnected system of the Virginia Public Service Co. had, at the time of the extension, an installed capacity of 43,430 kw. in steam, 14,266 kw. in hydro, and 152 kw. in Diesels. By installing the new unit in a building adjacent to the existing Alexandria plant, instead of in a new plant, the purchase of a new site was eliminated and the operating cost reduced by having the existing and the new plant operated by one crew.

This arrangement, however, imposed a restriction. With the existing intake using water from the Potomac River, only about 5000 kw. additional capacity could be installed. Accordingly, it was decided to install a 5000 kw. turbine generator unit, generating at 650 lb. ga., 750 deg. F., with one 60,000 kw. Combustion engine bent tube boiler and economizer. The boiler is arranged for stoker firing with a Westinghouse forced draft six retort link grate stoker with continuous ash discharge.

As continuous service of this unit was of primary importance, it seemed advisable at the time to use a moderate superheat temperature and 750 deg. F. steam temperature was, therefore, selected.

Since stoker firing is used, no air preheater was needed and the ecomonizer is of sufficient size to handle incoming feedwater of 212 deg. F. This simplifies the heat cycle by elimination of any high pressure heaters after the deaerating heater, which is supplied with steam from the stoker drive exhaust, the boiler feed pump turbine exhaust or steam from the evaporator. The temperature in the deaerating heater is controlled by a Minneapolis Honeywell pressure actuated control

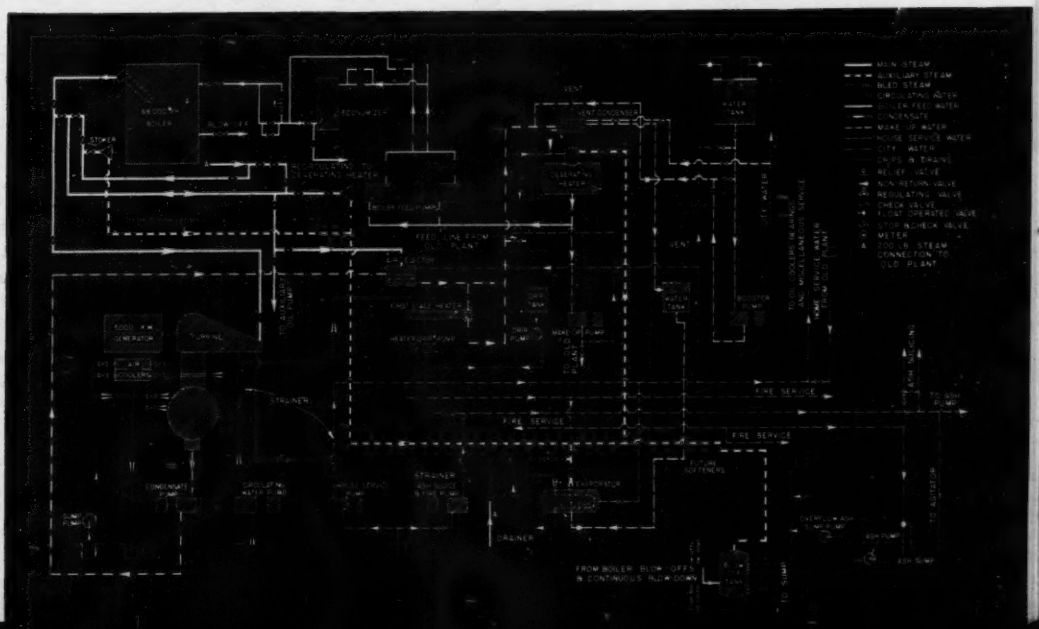


Fig. 8. Flow diagram of the Alexandria Plant extension with one turbine and one 650 lb., 750 deg. F. C.E. boiler fired by a Westinghouse link grate stoker

bypassing the low pressure heater if excess steam is supplied in the deaerating heater.

Due to the plant's proximity to a residential district, a Cottrell precipitator of sufficient capacity to handle the gases of the old and new boilers was demanded by the City Council. The new unit was put in operation in December, 1936, and has been in regular operation since that time.

West End Station

Before the rehabilitation program, the West End Plant of the Keystone Public Service Co. at Oil City, Pa., included five 500 hp. boilers, supplying steam to three 200 lb. turbines with a capacity of 6000, 1500 and 5000 kw. each. The addition to the station consists of a new steam generating unit and a 5000 kw. turbine. Although the boiler was designed to operate at 675 lb., 700 deg. F., it is now being operated at 200 lb. pressure, 600 deg. F., supplying steam primarily to a newly-installed 200 lb., 5000 kw. turbine, and the excess to the other turbines. Future plans call for the installation of a high pressure topping turbine. When this is done, the boilers will be operated at 675 lbs., and the topping unit will exhaust to the present 5000 kw. turbine. The boiler is pulverized coal fired by a 5 t. mill and preheated air for coal drying is supplied at temperature of 350 deg. F. by a separate steam heated air heater.

The steam generator is of unusual design, consisting of a two drum bent tube boiler, two independent water-cooled furnaces, a single superheater, economizer, forced and induced draft fans. The rated capacity is 100,000 lb. of steam per hr. The layout provides a large percentage of furnace cooling in a low head room design. The overall dimensions are approximately 27 ft. wide, 25 ft. deep and 30 ft. high. The boiler furnace and superheater are placed between twin, water-cooled furnaces, housed in a single steel casing. One burner is installed in the front wall of each furnace. Gases from the burners travel toward the rear of the furnace and turn backward 180 deg., finally leaving the furnace through vertical, water-cooled, slag screens at the front of the inner side walls. Ash is removed from the dry type ash hoppers by hydraulic sluicing.

After passing the screen, the gases flow past the vertical convection superheater tubes and divide between two vertical parallel banks of boiler tubes, as shown by Fig. 3. The superheater is situated in the center in front of the main boiler tube bank and consists of three multiple loops. The two horizontal headers are placed inside of the boiler casing below the burners, and are protected by brickwork.

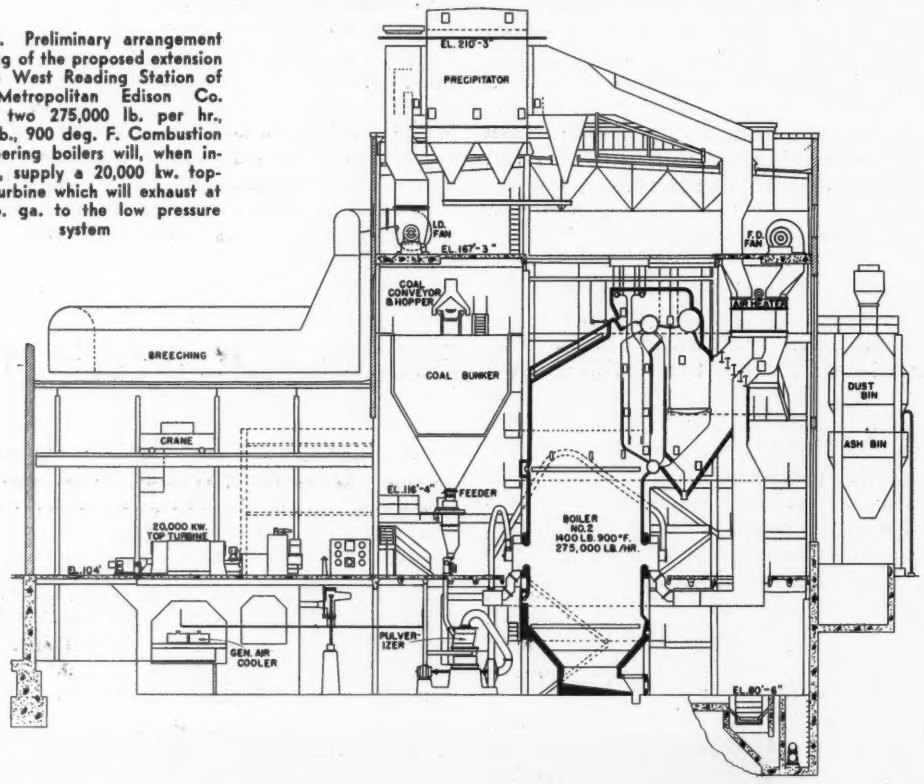


Fig. 9. Preliminary arrangement drawing of the proposed extension of the West Reading Station of the Metropolitan Edison Co. These two 275,000 lb. per hr., 1400 lb., 900 deg. F. Combustion Engineering boilers will, when installed, supply a 20,000 kw. topping turbine which will exhaust at 265 lb. ga. to the low pressure system

After passing the boiler tube bank, the two streams of gases combine and flow to the economizer downward to the induced draft fan on the basement floor, hence out the stack. The low fusion ash coal used necessitated a large amount of water-cooled radiant heat absorbing surface in the furnace and this surface was obtained by the installation of the additional water-cooled side walls, which practically doubled the area normally installed in a single furnace of the same general design and same total volume. The effective furnace volume is 6280 cu. ft. and the heat release at full load about 21,500 B.t.u. per hr. per cu. ft.

Draft loss through the boiler and economizer is less than 2¼ in. and but ¾ in. at full load. When one

furnace is operated alone, the steam temperature ranges from 590 deg. F. at 30,000 lbs. per hour to about 625 deg. F. at 50,000 lb. per hr. When both furnaces are in use for higher load, the temperature drops, ranging from about 590 deg. F. at 60,000 lb. per hr. to 600 deg. F. at 70,000 lbs. per hr. and from this point on to the full load of 100,000 lb. per hr. remains practically constant. The flue gas temperature leaving the economizer at full load is somewhat less than 400 deg. F. This boiler installation has proven to be simple, accessible, and reliable in operation. It responds quickly and steadily to changes in load demands and shows extremely small carryover at any rating.

The station at present has a B.t.u. rate of approximately 22,000 per kw-hr. and the proposed topping unit will reduce this rate to 17,800.

Seward Plant

Seward, a "mine-mouth" plant of the Pennsylvania Electric Co., is located a few miles from Johnstown, Pa., on the Connemaugh River and originally had installed in it two 20,000 kw. turbo-generators with jet condensers. The first step in the program for this plant was the replacement of one of the jet condensers by a surface condenser and reinforcing the turbine steel support to provide a smoother running machine, and in rebuilding each turbo-generator for 25,000 kw. capacity at 80 per cent power factor.

The second step was the addition of two Babcock & Wilcox 725 lb., 825 deg. F. boilers of 200,000 lb. per hr. capacity each. These boilers are fired by Taylor water-cooled stokers, each boiler being installed in space provided in the original plant construction for a boiler of 100,000 lb. per hr. capacity. A cross-section of the boiler is shown by Fig. 4. The piping was so arranged that the new boilers could feed steam to the existing 275 lb. pressure plant through a reducing valve and desuperheater. The original hot process lime soda feedwater treatment was changed to cold sedimentation, filtration and softening with chemical feed pumps to inject sulphite, sulphate and phosphate into the feed water system.

The third step will consist of a new addition to the turbine room to house a 35,000 kw. turbo-generator, hydrogen cooled, the turbine being built for 650 lb. pressure, 825 deg. F. The installation of this unit has been deferred for the present due to load recession.

Only one extraction point on the new turbine will be used, and the rest of the steam required for feed water heating will be obtained from the boiler feed pump turbine. The low fuel cost at this plant makes it uneconomic to install a more efficient feedwater heating system. The generator is designed for 11,000 v. and delivers its output to a bank of three 12,500 kv-a. transformers, with a bank overload rating of 50,000 kv-a., which step up the voltage to 110 kv.

Diesel Power Station Operation

By John M. Drabelle,

Mechanical and Electrical Engineer
Iowa Electric Light & Power Co.
Cedar Rapids, Ia.

From a background of 14 yr. experience with 12 stations the author discusses Diesel power station operation before the Midwest Power Conference

EXPERIENCES AND CONCLUSIONS contained in this paper embrace fourteen years of experience with Diesel engine operation in Central Station Service. In this group are twelve stations with a total of thirty-one engines installed. The several power stations are operating under the following three classifications: Stand-by, peak load, and continuous. The engines operated were the product of several manufacturers in the United States and in type classification are as follows: Four-cycle air injection, four-cycle solid injection, two-cycle solid injection pump scavenged, two-cycle piston scavenged-cross head type, and two-cycle crank case scavenging solid injection.

Based on this experience of 14 yr., certain milestones stand out clearly in the path of experience. Too much care and detailed attention in the selection of auxiliary equipment, after the prime mover is purchased cannot be given to these very important adjuncts of a Diesel plant. Adequate cooling towers or spray ponds, adequate water cooling pumps, at least, in duplicate and preferably in triplicate should be provided for the handling of the raw water cooling supply.

Heat exchangers for water to water service and water to oil service are in many cases too small in size. Theoretically they are of correct size, but when the inevitable slight accumulation of dirt, slime, scale and wax is deposited on the tubes in combination with the hot sultry day, the heat transfer rate is so reduced that inadequate cooling is the inevitable result, and an overheated engine results.

Water Treatment

The treatment of water used for cooling and circulating purposes in a Diesel engine plant is another source of possible trouble as practically all water contains certain scale forming impurities. It is true that the amount of temporary and permanent hardness varies with this water in different localities, but nevertheless these scale forming substances must be removed. A simple, satisfactory manner of doing this is by means of the zeolite type of softener wherein by means of the zeolite and a solution of common salt the calcium and magnesium constituents in the water are exchanged in the zeolite for sodium salts which are not scale forming.

Due to the evaporation in the cooling pond or tower, this water loss must be continuously replaced

and occasionally the concentrated solution that forms in the cooling basin must be drawn down to reduce concentration. A softening system is essential whether heat exchangers are used or not for the reason that scale in untreated water will form in the tubes of the heat exchanger unless the water is treated. The amount of water replaced by evaporation usually amounts to from 1 to 3 gal. per hp. hr. depending on wind velocities, the type of cooling system used and the humidity.

There are two means of dissipating the heat in the cooling water. One is by means of the cooling tower which consists of a series of shelves over which the cooling water falls and the other is the spray pond. Both are satisfactory but in some few localities the cooling tower, on account of wind velocities with high driftage loss, has certain advantages over the spray pond. Cooling the water to within 10 deg. F. of the dry bulb temperature means little for the reason that it is the wet bulb temperature that really determines the ability to cool. A good tower or spray pond should cool to approximately 10 to 12 deg. F. of the wet bulb reading.

Air and Oil Filters

Oil filters should be installed upon both the fuel oil lines and the lubricating oil lines, so as to remove from the system any dirt or other material that may be floating in the respective oil streams. Oil centrifuging equipment for removing dirt, suspended carbon, water and other material from the lubricating oil supply is a most desirable and money-saving plant auxiliary as it will save quantities of lubricating oil that in many cases as soon as fouled is thrown away.

Pyrometers are absolutely necessary in order that the operator may know the load and load balance carried on each cylinder of the engine and if excess temperatures are found to properly correct the same before serious damage results.

The solid injection fuel oil nozzles are quite critical in adjustment in all makes of engines of this type, and a fuel oil injection nozzle testing pump with its gage is a most necessary piece of equipment in the power station in order to maintain nozzles to good spray efficiencies.

Due to the dust storms of recent years, particularly in the Western territory, the air filter has shown itself to be a most necessary piece of equipment in the power station. The quantity of dust carried into the working cylinders of an engine under dust storm condition will result in fouling of the lubricating oil and extra wear and possibly scoring of the pistons and cylinders.

Too often the statement is made that a Diesel engine can burn anything. It possibly can, but with what results in fuel consumption and engine damage is another matter. For many years all fuel oil received by our companies has been checked in a central chemical laboratory before unloading and numerous cars have on the results of the laboratory's findings been rejected. It is our experience that specific gravity of fuel oil means but little; viscosity, fire, flash, ash and Conradson Carbon number are now regarded as most important items. A good alert operator will often refer to an oil as good or bad and say, "Listen to it." This is really a measure by them by ear and sound of the cetane number of the fuel oil.

The statement is often made that anybody can run a Diesel engine. This is doubtless true. They can run it, but how well can they run it? Experience of 14 yr. seems to show that a well trained, well paid, happy satisfied crew of men in a Diesel power station is absolutely essential for high continuity of service, good operating results and low maintenance. The best Diesel operators seem to be a peculiar combination of a machinist and a watch engineer. The man must be alert, must have a good ear for sounds, a quick and a clear thinker, and a very careful observer.

For successful operation of a Diesel power station adequate plant records are most essential. These should take the form of a daily report on the engine operation on which is recorded hourly the various temperatures, such as, water inlet, and water outlet, lubricating oil, exhaust temperatures, water temperatures leaving cylinder, the readings on fuel oil meter, and the usual electrical data of voltage amperes, and kilowatt load carried on the unit. The monthly report, of course, is a function of the Accounting Department, and for the best all around picture of operating results, we have found that a report which shows the money expended in dollars for maintenance, superintendence and labor, fuel, water, water softener chemicals, lubricants, miscellaneous supplies, the gross generation of the station, the amount of station auxiliary power in kilowatt hours and the amount of station unaccounted for in kilowatt hours.

This combined with certain miscellaneous data consisting of the cost of fuel oil per gallon at the station, cost of lubricating oil per gallon, number of gallons of fuel, and the lubricating oil used, the net kilowatt hours per gallon of fuel oil and lubricating oil, and the station labor hours of maintenance and operation. The unit costs are expressed in cents per kilowatt hour net output. The net output is what the station has to deliver to either a factory or a power sysem and not the gross generation. Too often alleged statistics and alleged engineering reports of Diesel projects deal only in gross generation.

Silencing, Noise, and Smoke

It is not uncommon for people residing in the neighborhood of a Diesel power station to complain of noise, smoke, vibration and odor. The problem of exhaust noise and air intake noise can be readily solved by the use of proper silencing equipment. In some extreme cases wave traps have been used to break up the low frequency waves that are below the range of audibility but do seriously effect the shaking of windows and doors in homes and buildings adjacent to the power station. The ordinary conventional cast iron muffler pots are inadequate to properly silence an engine exhaust.

Low frequency noise of air compressors, either of the scavenging type or supplying air for air injection systems or both are serious offenders and require special treatment with special apparatus by those familiar and conversant with this most difficult accoustical problem. In respect to vibration this can usually be taken care of by isolating the foundation.

Investment Returned 34 Per Cent

Modernized power plant of Jacob Dold Packing Co. saved $38,579 in one year as shown by records described here.

By HARRY P. DEMPSEY

Consulting Engineer
Buffalo, N. Y.

IN THE May 1937 issue of POWER PLANT ENGINEERING the Jacob Dold Packing Company's power plant rehabilitation was described in detail. The basic idea in engineering design of this problem was not that of a "show" plant, but rather to use any available existing auxiliary equipment possible until such time that the savings made by the major investments would pay for themselves and provide for replacement of this equipment without new appropriation.

During the fiscal year of 1936 this plant saved $38,579.00 or 34 per cent return on the investment on coal and purchased power alone. This saving does not represent one cent for reduction in labor or any other item than fuel and purchased power and is based upon an 8-yr. average, 1928-1935, for comparison.

Complete daily operating records are kept and compiled by fiscal month. The data used in this article to obtain the cost of steam and power is taken from actual exact cost figures and meter readings throughout the plant. The fiscal month of November, a period of 5 weeks or 35 days, was chosen as it included about all the variable working conditions.

The following list of 35 items to break down a cost for steam may look lengthy and difficult, but in giving them a little study it will be found that they are most simple. This modern plant is equipped with coal pulverizer, water walls, air preheater, forced and induced draft fans, turbine driven boiler feed pump and complete feedwater treatment, cold process.

TABLE NO. 1, COAL & ASH, COST & HANDLING

Item No. 1 is Fuel, in this case coal with a cost of $3.91 delivered. This item should include cost of coal at mine, freight charges, demurrage, etc.

Item No. 2, Pulverizer—the drive for feeding coal or fuel to boiler, in this case electric driven pulverizer, took 50 kw. at 24 hr. a day for 31⅓ days, or a total of 37,596 kw-hr. listed in second column.

Item No. 3, Coal Conveyor—it was found by test that this bucket conveyor utilized 1.5 kw. per ton of coal, handled 2569.85 tons, utilized 3855 kw. listed in second column.

Item No. 4, Ash Removal—by steam flow meter readings the removal of ash from furnace bottom every

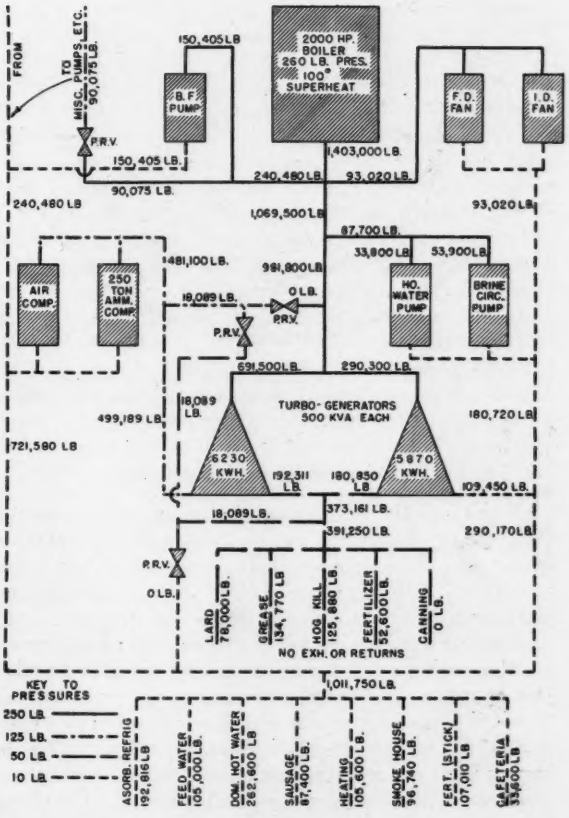


Fig. 1. Steam distribution diagram for typical day at Jacob Dold Packing Co.'s plant corresponding to records shown in Figs. 2 to 5

4 hr. amounted to 0.73 per cent of total load, or 340,000 lb. of steam entered in first column.

Item No. 5, Maintenance and Repair Item, Pulverizer—job cost during month $59.73, entered in cost column.

Item No. 6, Maintenance and Repair Item, Coal Conveyor—$68.31 entered in cost column.

Item No. 7, Maintenance and Repair Item, Ash Handling Equipment—maintenance and repair for month amounting to $216.04, entered in cost column.

Item No. 8, Miscellaneous Repair in Boiler Room, item of $53.55, of which 25 per cent is taken and allotted to coal handling equipment and entered as $13.39 in cost column.

Item No. 9, Labor—Coal and Ash Handling—25 per cent of total labor cost for month of $1512.82 or or $378.21, entered in cost column.

All of the above items, Nos. 1 to 9 inclusive, pertain to coal delivered to boiler and ash removal from same and carries a total of $10,781.28, which is 80.3 per cent of total cost of steam.

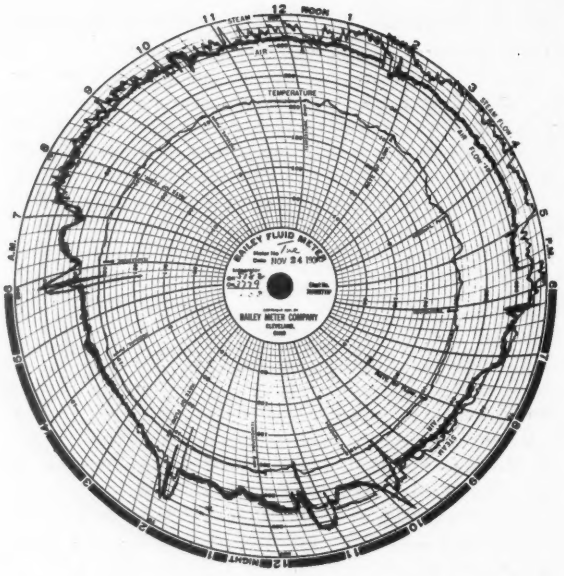


Fig. 2. Graphic Record of steam and combustion air flow, and feedwater temperature. Coincidence of steam and air flow lines indicate a CO_2 of 14.5 to 15 per cent

Feedwater and Treatment

Item No. 10, Feedwater to Boiler, comprises the total steam production of 46,576,600 lb. of water to steam, plus the continuous blow down which amounted to 5600 lb. per hr., or 4,211,200 lb. plus 154,000 lb. blow down from old boilers (on temporarily) or a total of 50,941,000 lb. There being 25 per cent returns from plant, 75 per cent of the above figures taken or 38,205,750 lb., plus 155,625 lb. filter backwash, or a total of 38,361,000 lb. of water at 6.4 mills per thousand pounds, or $245.51, entered in cost column for water. The old boilers were on for three and two thirds days for inspection of new unit during this month. The filter backwash amounted to 3750 gal. of water per week for five weeks.

Item No. 11, Heating of Feedwater—this item is very important and is very often overlooked on cost accounting for boiler room practice. From the above figures in Item No. 10 for Feedwater it will be noted that we are heating 38,205,750 lb. of water from 85 deg. to 204 deg., which is feedwater temperature. The raw water temperature was 47 deg., which is heated to 85 deg. by passing continuous blow down through coils in cold water basin.

As the steam and water are mixed in feedwater heater and it is found that approximately 10 per cent by weight of steam is required, deduct 3,820,575 lb. from total water or a net of 34,385,175 lb. of water to be heated from 85 to 204 deg. and requires 3,530,000 lb. of steam entered in Table 1, 1st column under steam.

Item No. 12, Feedwater Pumping, the turbine feedwater pump for new steam generating unit was found to utilize 4800 lb. of steam per hour at 250 lb. pressure, for 24 hr. and 31⅓ days per month, together with 2400 lb. per hr., old boiler feed pump, for 24 hr., 3⅔ days, making a total of 3,822,000 lb. of steam, entered in first column.

Item No. 13, Pumping to Hot Well, 200 lb. of steam per hr., times 24 hr., times 35 days—168,000 lb. of steam, in first column.

Item No. 14, Treated Water Pumping, it was found to take 11.75 kw. per hr. for 3 hr. per day for 35 days, or 1234 kw., under second column.

Item No. 15, Pumping to Oil Filters, it was found to take 0.75 kw. for 24 hr. for 35 days, or 630 kw-hr., under second column.

Item No. 16, Pumping Returns from Engine Room, same as Item No. 15, 630 kw-hr., under second column.

Table No. 1

COST OF STEAM

		Steam	*Elect. kw-hr.*	*Cost*
	COAL TO BOILER			
1.	Fuel—Coal			$10,045.60
2.	Pulverizer		37,596	
3.	Coal Conveyor		3,855	
4.	Ash Removal	340,000		
5.	M. and R. Pulverizer			59.73
6.	M. and R. Conveyor			68.31
7.	M. and R. Ash Removal			216.04
8.	Misc. M. & R. 25%			13.39
9.	Labor Coal and Ash 25%			378.21
	FEEDWATER AND TREATMENT			
10.	Feed Water—Water			245.51
11.	Feed Water Heating	3,530,000		
12.	Feed Water Pumping	3,822,000		
13.	Pumping to Hot Well	168,000		
14.	Pump. Treated Water		1,234	
15.	Pump. to Oil Filters		630	
16.	Pump. Ret. from Eng. Rm.		630	
17.	Misc. M. & R. 10%			5.36
18.	M. and R. Treat App.			13.64
19.	M. and R. Heaters, etc.			195.15
20.	Supplies			175.87
21.	Labor Water Treat. 10%			151.28
	BOILER AND OPERATIONS			
22.	Forced and Induced Draft Fans	2,745,000		
23.	Operating Labor 65%			983.33
24.	M. and R. Misc. 65%			34.81
25.	M. and R. No. 4 Boiler			37.89
26.	M. and R. No. 5 Boiler			38.80
27.	M. and R. No. 6 Boiler			9.65
28.	M. and R. No. 7 New Boiler			78.33
29.	M. and R. For. and Ind. Dr. Fans			205.22
30.	Supplies			26.76
31.	Rep. to Bldgs.			7.28
	FIXED CHARGES			
32.	Deprec. Equip. and App.			327.00
33.	Deprec. Bldgs.			80.00
34.	Taxes on Real Estate			11.50
35.	Insur. on Equipment			9.50
	TOTAL		43,945	$13,418.16
	Items No. 4 + No. 11	3,870,000		
	Items No. 12 + No. 13 + No. 22—No. 11 = 3,205,000 Steam 250 lb. = 100%, 10 lb. = 91.7%			
	Diff. 8.3% of 3,205,000	266,000		
		4,136,000		

Item No. 17, Miscellaneous Maintenance and Repair Item, 10 per cent of $53.55, or $5.36, under cost column.

Item No. 18, Maintenance and Repair Item, water treatment apparatus, $13.64 in cost column.

Item No. 19, Maintenance and Repair Item, water heaters, etc., under cost column, $195.15.

Item No. 20, Supplies for Water Treatment alone, $175.87 under cost column.

Item No. 21, Labor Water Treatment, 10 per cent of $1512.82 or $151.28 in cost column.

Item Nos. 10 to 21 inclusive, feedwater treatment, amount to a total of $786.81, or 5.88 per cent of total cost for steam.

Boiler and Operation Cost

(*Other than Coal and Ash and Feedwater*)

Item No. 22, Steam required for Forced and Induced Draft Fan Turbines, by steam flow meter it was found to be 3650 lb. per hr. for 24 hr. or 31.33 days or 2,745,000 lb. of steam, under first column.

Item No. 23, Operating Labor, 65 per cent of $1512.82 or $983.33, in cost column.

Item No. 24, Miscellaneous Maintenance and Repair Item, 65 per cent of $53.55 or $34.81 entered in cost column.

Item No. 25, Maintenance and Repair Item, No. 4 Boiler, $37.89 entered in cost column.

Item No. 26, Maintenance and Repair Item, No. 5 Boiler, $38.80 entered in cost column.

Item No. 27, Maintenance and Repair Item, No. 6 Boiler, $9.65 entered in cost column.

Item No. 28, Maintenance and Repair Item, New No. 7 Boiler, $78.33 entered in cost column.

Item No. 29, Maintenance and Repair Item, Forced and Induced Draft Fans, $205.22 entered in cost column.

Item No. 30, Supplies, $26.76 entered in cost column.

Item No. 31, Repairs to Buildings, $7.28 entered in cost column.

These items, Nos. 22 to 31 inclusive, amount to 1422.07 for boiler and operation, or 10.62 per cent of total cost of steam.

Fixed Charges

Item No. 32, Depreciation Equipment and Apparatus, 5 per cent of $78,488.78, or $327.00 per month, entered in cost column.

Item No. 33, Depreciation Building, 5 per cent of $19,155.49 or $80.00 per month, entered in cost column.

Item No. 34, Taxes on Real Estate, prorated for boiler room, $11.50 per month, entered in cost column.

Item No. 35, Insurance on Equipment, prorate of boiler insurance $9.50 per month, entered in cost column, making total fixed charges of Items 32 to 35 inclusive, amounting to $428.00 or 3.2 per cent of total cost of steam.

The total of the cost column amounts to $13,418.16, which is the actual cost of steam generated during this month. The amount of steam generated must not be based upon the gross amount of 46,576,600 lb. of steam, but rather on the net amount after deducting the amount of steam necessary for driving boiler feed pump, forced and induced draft fans, water pumping and feedwater heating (Table No. 1—Column 1) together with the equivalent amount of steam necessary to generate the number of kilowatt hours in the second or electric column listed (Table No. 2—Item 13) which gives a net amount of 42,150,563 lb. (Table No. 2—Item 15).

In order to arrive at the net amount of steam delivered to the plant it is necessary to first deduct the amount of steam used to develop steam or that amount used by the auxiliaries to develop steam. These auxiliaries are both steam and electrically driven and by referring to Table No. 1 in first and second columns, an explanation or description of the method used will be given. The items to be considered in the steam driven auxiliaries are Nos. 4, 11, 12, 13 and 22. No. 4, Ash Removal, steam is obtained through the 250 to 125 lb. pressure regulating valve and this steam is gone with the ashes and should be charged as 250 lb. steam with no credit. Item No. 11, Feedwater Heating, is 10 lb. exhaust steam and is obtained through the other auxiliaries such as Items 12, 13 and 22. Adding together Items 12, 13 and 22 we have a total of 6,735,000 lb. of 250 lb. steam used to drive these auxiliaries. Of this amount 3,530,000 lb. of exhaust or 10 lb. steam from these auxiliaries is used for heating feedwater, leaving a balance of 10 lb. steam unconsumed of 3,205,000 lb. By thermal value of steam, the 250 lb. steam at 100 deg. superheat has a total heat of 1266 B.t.u. while 10 lb. exhaust steam has a total heat of 1160 B.t.u. Assuming the 250 lb. steam to be 100 per cent then the 10 lb. steam is equal to 91.7 per cent or a difference of 8.3 per cent. Taking 8.3 per cent of 3,205,000 lb. of steam we have 266,000 lb. of equivalent 250-lb. steam chargeable to auxiliaries. The balance of 91.7 per cent of this steam is used elsewhere in the plant at 10 lb. pressure, and is therefore credited to this operation. Therefore summing up we have Items Nos. 4 and 11 amounting to 3,870,000 lb. plus 266,000 lb. or a total of 4,136,000 lb. of 250 lb. steam chargeable to auxiliaries.

The next column being the electric column totals 43,945 kw. From Table No. 2 it is found that by method shown 1 kw. is generated by 6.6 lb. of 250-lb. steam and therefore the total electric column of 43,945 x 6.6 or 290,037 lb. of steam, plus the steam column of 4,136,000 lb. or a total of 4,426,037 lb. of steam necessary to generate steam.

Subtract this amount of 4,426,037 lb. of steam from 46,576,000 lb. of steam there remains a net amount of steam developed of 42,150,563 lb. of steam. Dividing

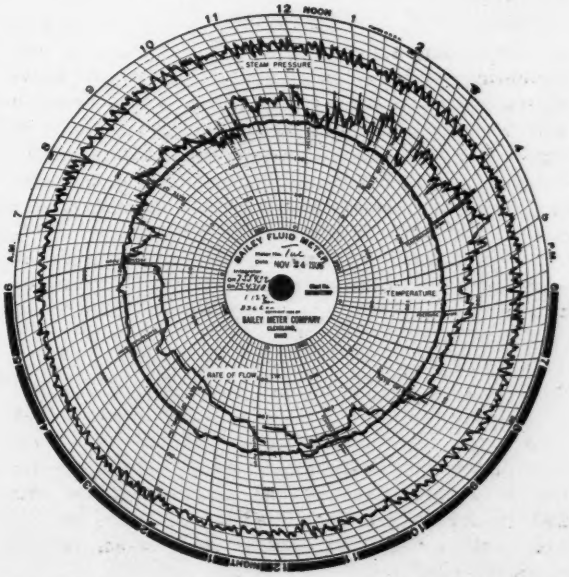


Fig. 3. Steam pressure at the boiler, flow of 50-lb. steam from turbines, and temperature of steam at the boiler

the total cost in the third column of $13,418.16 by the above amount of steam allows 31.83c per 1000 lb. of steam developed.

Under Fixed Charges for the boiler room the depreciation of equipment and apparatus contains the new investment of $71,864.61.

Table No. 2

Steam to Generators

In Table No. 2 we arrive at the amount of steam delivered to generators for electric power, starting in with Item No. 1, giving the total amount of steam generated by the boiler.

Item No. 2 is a separate isolated pump line taken off through a 250 lb. to 125 lb. reducing valve and amounting to 6.42 per cent of total steam developed by steam flow meter.

Item No. 3, Feedwater Pump, is the amount of steam taken from Item No. 12 of the first table.

Item No. 4, Forced and Induced Draft Fans, the amount of steam taken from Item No. 22 of the first table.

Item No. 5, Steam Brine Pump, which ran for 259 hr., consuming 5400 lb. of steam per hr. by steam flow meter.

Item No. 6, Steam Water Pump, ran 581 hr. at 3000 lb. per hr. by steam flow meter. Items 2 to 6 inclusive, a total of 12,698,800 lb. of steam is to be deducted from the total gross amount developed, leaving a balance of 33,877,800 lb. of 250 lb. steam to the turbine generators.

Item No. 7, total amount of 250 lb. steam to turbine generators by 1266 B.t.u. per lb. of steam at 250 lb., 100 deg. superheat.

Item No. 8, 125 lb. steam bled from one unit by 1192 B.t.u. per lb. of steam at 125 lb. pressure.

Item No. 9, 50 lb. steam bled and exhaust by 1179 B.t.u. per lb. of steam at 50 lb. pressure.

Item No. 10, is the amount of 10-lb. steam exhaust at 1160 B.t.u. per lb. of 10 lb. steam pressure.

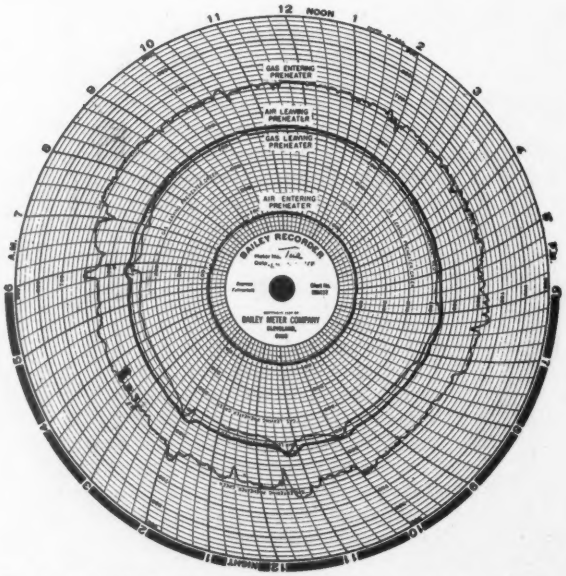


Fig. 4. Air preheater temperature chart—outer curve, gas entering; next, air leaving; next gas leaving; inner curve, air entering

Table No. 2

STEAM TO GENERATORS

1.	Total Steam			46,576,600 lb.
2.	Boiler Rm. 250—125 lb. Misc. Pumps		2,990,200	
3.	Boiler Feed Pump.....		3,822,000	
4.	For. and Ind. Dr. Fans...		2,745,000	
5.	Steam Brine Pump.....		1,398,600	
6.	Steam Water Pump.....		1,743,000	12,698,800
	Net Steam to Generators			33,877,800 lb.
7.	250 lb. 33,877,800×1266 B.t.u.			42,889,294,800
8.	125 lb. 14,700,000×1192 B.t.u.		17,342,400,000	
9.	50 lb. 9,789,700×1179 B.t.u.		11,542,056,300	
10.	10 lb. 9,388,100×1160 B.t.u.		10,890,196,000	39,774,652,300
				3,114,642,500

11. $\frac{3,114,642,500}{1266} = 2,460,000$ lb. Steam at 250 lb. pressure chargeable to Generators
12. $\frac{2,460,000}{373,000 \text{ kw-hr.}} = 6.6$ lb. Steam per kw-hr.
13. 43,945 kw-hr. × 6.6 lb. = 290,037 lb. Steam at 250 lb. pressure.
14. Steam—(Total Col. 1—Table 1) 4,136,000 lb.
    Total items 13 and 14 4,426,037 lb.
15. 46,576,600—4,426,037 = 42,150,563 lb. Steam net to plant.
16. $\frac{\$13,418.16}{42,150.6} = 31.83$c Cost per 1,000 lb. steam.
17. Cost of Steam for Elect. Power.
    Item 11—2,460 × 31.83c = $783.02

Item No. 11, by deducting the total amount of Items 8, 9 and 10 from Item No. 7 we have a total of 3,114,642,500 B.t.u. utilized by turbine generators in making electricity. To reduce this heat value to pounds of steam at 250 lb., 100 deg. superheat, we divide by 1266 B.t.u. giving 2,460,000 lb. of steam.

Item No. 12, this amount of Item No. 11—2,460,000 lb. of steam is divided by the total amount of kilowatts produced being 373,000, which in turn results in 6.6 lb. of steam per kilowatt hour.

Item No. 13, The amount 43,945 kw-hr. is the total electric current required to generate electricity, the total of Column No. 2, Table No. 1 and multiplied by 6.6 lb., Item 12, Table No. 2, amounts to 290,037 lb. of steam at 250 lb. pressure.

Item No. 14, The amount 4,136,000 lb. of steam is taken from Table No. 1, Total of Column No. 1 and described previously. The total of Items Nos. 13 and 14 is 4,426,037 lb.

Item No. 15, From the total steam generated Table No. 2, Item No. 1, 46,576,600 lb. deduct the equivalent amount of steam required to make steam 4,426,037 lb. which allows 42,150,563 lb. net 250-lb. steam to plant.

Item No. 16, The total cost of $13,418.16 chargeable to manufacturing of steam divided by the net steam 42,150.6 results in the cost of 31.83c per 1000 lb. steam.

Item No. 17, The amount of steam, Item No. 11 chargeable to generators multiplied by cost of steam per 1000 lb. in Item No. 16, 31.83c results in $783.02.

Table No. 3

Cost of Electricity

Referring to Table No. 3 to arrive at the cost of electric current we have Item No. 1, steam taken from Table No. 2, Item No. 17, of $783.02.

Item No. 2, Labor 30 per cent of total engine room labor amounting to $2224.30 or $667.29.

Item No. 3, 30 per cent of $196.21, Miscellaneous Repairs in Engine Room, or 58.86.

Item No. 4, Repairs to Turbine Generator No. 1, $4.71.

Item No. 5, Repairs to Turbine Generator No. 2, no cost in cost column.

Item No. 6, Repairs to Buildings, 30 per cent of $265.44 or $79.63.

Item No. 7, Supplies, Extra Heavy Oil for generators, $33.18.

Item No. 8, Miscellaneous Supplies, 30 per cent of $135.53, or $40.66.

Item No. 9, Taxes, 30 per cent of $13.75 prorated, $4.13 in cost column.

Item No. 10, Depreciation, actual depreciation based upon electrical equipment in engine room of $41,789.33 and on buildings of $8030.37, a total of $49,819.70, which is $207.58 per month. The total cost of the above is $1,879.06 or a total cost of generating electricity.

Of the total amount of 373,000 kw-hr. generated during the month, 43,945 kw-hr. were used in developing steam, leaving a net of 329,055 kw-hr. and this amount divided into the total cost of $1879.06 amounts to 5.7 mills per kw-hr., but the actual cost of the total kilowatt hours generated is $1879.06 divided by 373,000 or 5.0 mills per kw-hr.

In analyzing the labor and certain conditions in the engine room, the figure of 30 per cent of cost of operation and maintenance was established. The amount of $49,819.70 is 38 per cent of the total value of engine room upon which depreciation is based and of this amount $41,789.33 is new equipment and $8030.37 is on Buildings. The balance of 62 per cent is refrigeration, hot and cold water, compressed air, etc.

The percentage figure of 30 per cent used as cost of operation and maintenance in engine room was arrived at by a study of the time and labor conditions, the balance of the 70 per cent being made up of 55 per cent for refrigeration, 10 per cent for air and 5 per cent for water.

The readers' first reaction to this article will probably be that this set-up does not fit his problem. This fact is undoubtedly true as we know that every industrial power plant is different in equipment and apparatus, type of fuel and handling, feedwater treatment and application of steam and power. It is the intent only, to show how this problem was met under these conditions and point out that a similar set-up can be made, differing to meet your obligations.

TABLE No. 3

COST OF ELECTRICITY

1.	Cost of Steam, Item 17—Table 2	$ 783.02
2.	Labor 30% Eng. Rm. Labor	667.29
3.	Misc. Repairs 30% Eng. Rm	58.86
4.	Main and Rep. Gen. No. 1	4.71
5.	Main and Rep. Gen. No. 2	.....
6.	Rep. to Bldgs. 30% of Eng. Rm	79.63
7.	Supplies Turb. Oil	33.18
8.	Misc. Supplies 30% of Eng. Rm	40.66
9.	Taxes 30% of Eng. Rm	4.13
10.	Depreciation Eng. Rm. Equip. & Bldgs	207.58
	Total Cost	$1,879.06
	Total kw-hr. Generated Gross 373,000	
	Col. 2—Table 1 43,945	
	Total kw-hr. Generated Net 329,055	

$1,879.06 ÷ 373,000 = 5.0 mills per kw-hr. generated.
$1,879.06 ÷ 329,055 = 5.7 mills per kw-hr.—Net delivered to plant.

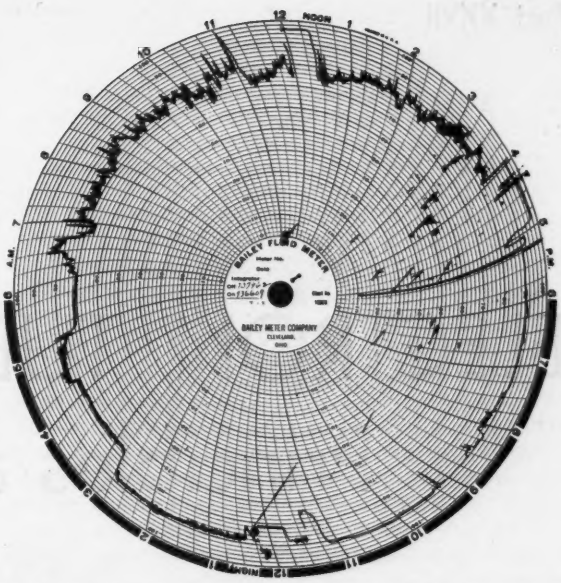


Fig. 5. Steam flow chart showing entire amount of 125-lb. steam bled from turbines

The very idea of this article is not that of using this set-up as a standard of operation in any respect or to show this plant to be above or below the average, but rather to bring out a method of "digging in" and bringing to light "all" of the items possible that can be charged against cost of steam and power.

Separating costs into items is done for one purpose only and that of comparison month to month with the idea of reducing costs such as method of water treatment, handling of fuel, etc.

The cost of steam might seem rather high in the figure of 31.83 cents per 1000 lb. with modern and up-to-date equipment, but if all items in the plant that go to make up the cost of steam are definitely included, then the above figure may be used for comparison. Note the following:

Coal to Boiler	$10,781.28	80.30%
Feedwater	786.81	5.88%
Boiler Operation	1,422.07	10.62%
Fixed Charges	428.00	3.20%
	$13,418.16	100.00%

The main item of fuel alone, "not" delivered to boiler, is $10,045.60 or 75 per cent of the total and of that figure 56½ per cent is freight or $5627.97.

The cost of electricity actually costing something may be a surprise and that figure amounting to a little over one-half cent per kilowatt hour. The charge of $1879.06 is correctly distributed for a five week period but is practically eliminated if power is not generated. The steam cost includes only the difference between the initial 250 lb. steam and the various pressures taken from the generators—the same amount of steam would be used if power was not generated but at a lower pressure. Practically all the other items would be redistributed in engine room and bring up the cost of refrigeration, water, air, and other services.

Part XXVII

The movement of a pen across the paper chart of a recording instrument, despite the fine balance of modern instrument design takes a great deal more power than is available in the coils of our more sensitive measuring instruments. Until recently, such instruments could not be had in the recording form, but here, as in other instances, the electron tube has "come to the rescue" and provided new recording instruments that are just as sensitive and accurate as the most sensitive indicating instrument made.

ELECTRON TUBES— Principles and Applications

By A.W. KRAMER

THOSE OF US who ever had occasion to make measurements with a laboratory type mirror galvanometer may recall how sensitive they were and how intriguing it was to see the tiny spot of light dance across an extended scale sometimes halfway across the room. The inertialess pointer—the slender beam of reflected light from the mirror—somehow gave one a feeling of "control", of extension beyond the limits of mere matter. Such instruments are cumbersome and impractical for ordinary commercial use, but in the laboratory, where delicate currents have to be measured or detected, the mirror galvanometer occupies a place that can be approached by few other instruments.

In this form of instrument a tiny silvered mirror attached to the moving system of the galvanometer reflects a beam of light on a scale set up some distance from the moving element as shown in Fig. 1. The greater the distance between the scale and the mirror, the greater the deflection of the spot of light across the scale for a given movement of the mirror. When this arrangement is used with a D'Arsonval or Einthoven movement, an extremely sensitive galvanometer is obtained. With the scale at a distance of one meter and with either a D'Arsonval or Einthoven movement an order of sensitivity of 0.00001 microampere per millimeter deflection is obtained.

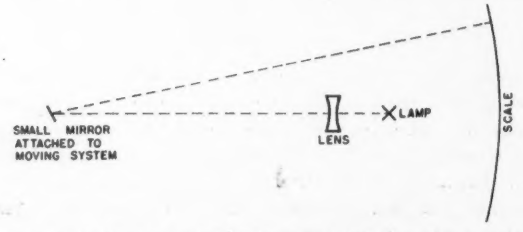


Fig. 1. The reflecting galvanometer uses a light beam as a pointer. A small mirror is mounted on the moving system of the instrument in such a way that it reflects the light from a lamp X on to an extended scale mounted some distance away from the moving element

It is quite evident that the extreme sensitivity of the reflecting galvanometer is due in large measure to the multiplication of motion offered by a long lever arm. The same result could be obtained by a long pointer attached to the moving system as is done with a shorter pointer in the ordinary portable instrument, but any pointer however thin and light has weight and mass and exerts a drag on the system which rapidly decreases the sensitivity as the length is increased. But a beam of light has no weight and so provides all the advantages of a long pointer with none of its limitations. The beam of light acts as an amplifier of the motion of the mirror which, naturally, is very minute.

For ordinary commercial and power measurements the extreme sensitivity of the reflecting galvanometer is unnecessary and the D'Arsonval type of instrument provided with a pointer or some form of alternating current instrument with a pointer is adequate; millions of them are in use. The light, tubular metal pointers used on these instruments exert negligible drag on the moving system.

In the case of recording instruments, however, the situation is not as simple as it is for indicating instruments. The usual direct acting recorders used in power stations are merely the heavier and higher torque counterparts of corresponding indicating instruments. When the electrical values to be measured are strong enough such recorders function entirely satisfactorily. They have highly desirable characteristics such as a continuous record and rapid response but because of the power required to actuate the recording pen they cannot be made to approach indicating instruments in sensitivity. The moving of a pen across paper takes a great deal more power than is available in the coils or circuits of ordinary indicating instruments. The friction of a pen across paper is from 100 to 1000 times as great as the friction in jeweled movement bearings. Thus, while indicating

instruments of the microampere class have been available for many years, conventional recorders, exemplified by the D'Arsonval type of instrument, have been available only in the *milli*-ampere class. Obviously, for many purposes—cases where alternating or direct currents of lower energy than it is possible to record by conventional recorders must be recorded—it is desirable to have a recorder that will have, say, the sensitivity of the reflecting galvanometer or even the standard microammeter or millivoltmeter coupled with the recording feature of the standard recorder.

The electron tube has made such recorders possible and in this article we will describe two types operating on different principles.

Naturally, the use of electron tube amplifiers is one of the first thoughts that comes to mind in a consideration such as this and it might be assumed that all we have to do is to amplify the weak impulses to be measured and recorded to a point where sufficient energy is available to actuate a recording pen.

The solution to the problem is not quite as simple as this, however. In many cases when such methods are studied, it is found that they possess certain inherent limitations which cannot be disposed of. It is, for example, difficult to amplify weak direct currents, so a method which might be feasible for use with alternating current could not be used with direct current. In other cases, the effects of ambient temperature or the necessity for skilled maintenance would prove detrimental. The two methods described in the following paragraphs, however, have none of these limitations.

The first method is a purely electrical method while the second in an electro-optical method involving the use of an intermediate optical system and photocells.

The first recorder which is one developed and marketed by the Westinghouse Electric & Mfg. Co. depends for its action on an additional coil mounted on the moving element of the measuring instrument. This coil does not add any appreciable work for the measuring element to perform; therefore, the accuracy or the torque requirement is not changed. The coil is used as a detecting or pilot coil and is placed

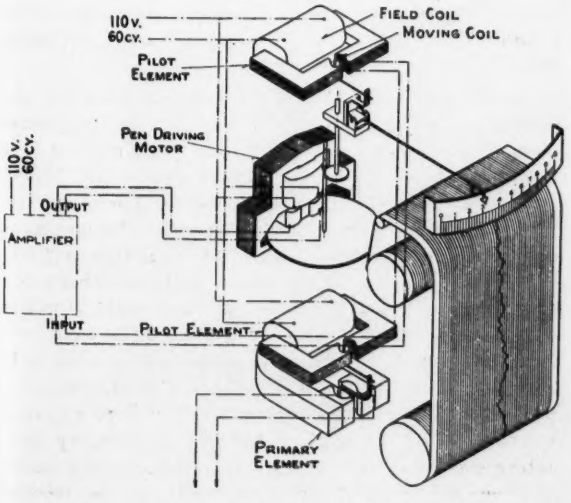


Fig. 2. Schematic diagram of the Westinghouse electronic recorder

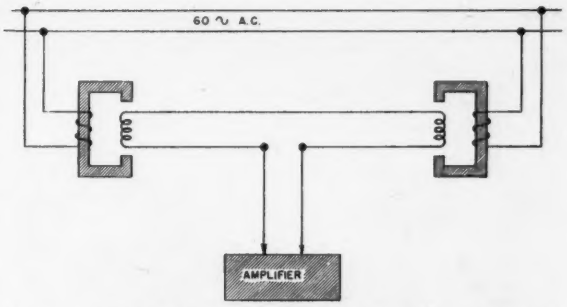


Fig. 3. A simplified diagram of the pilot coil connections in the Westinghouse electronic recorder

in the field of a stationary a.c. electro-magnet. The object of the pilot coil is to detect the position of the measuring element with respect to the electromagnet. A duplicate of this coil is mounted on the recording mechanism and arranged to operate in the field of a similar electromagnet excited from the same a.c. source. The relative position of these pilot coils is compared and controlled by their relative action on an auxiliary circuit. The current in this auxiliary circuit is amplified to give power sufficient to drive a high torque pen driving element.

A diagram of this electronic recorder is shown in Fig. 2. The primary element which may be any electrical instrument mechanism or measuring mechanism whose position depends upon the quantity being measured is mechanically connected to a pilot element which comprises a moving coil mechanism rotatable in an a.c. field. The moving coil of this pilot element is connected in series with the moving coil of the duplicate pilot element which is mechanically connected to the pen driving motor as shown in the schematic diagram. The moving coils of the pilot elements are connected in series opposing each other. The stationary fields of both pilot elements are connected in parallel to the same a.c. source as shown.

When the two pilot coils do not occupy the same relative positions in the a.c. fields, the voltages induced in the coils are not equal so that the output voltage is of a value depending upon the magnitude of this difference of position. This voltage is of the order of 50 millivolts per degree deflection. When the two coils occupy exactly the same relative positions, their voltages being equal and in opposition, no voltage is available at the terminals. The output of these coils is connected to the grid of the amplifier tubes of the power amplifier unit. The principle involved may be seen perhaps somewhat more clearly from the simplified diagram in Fig. 3. The a.c. output of the power amplifier is of the same frequency as the pilot element excitation.

The pen driving element is essentially a 2 phase motor of which one phase is continually energized from the same source of power as the pilot element electromagnet coils. The other phase is energized by the output of the electron tube power amplifier. The polarity and magnitude of the current in this phase of the motor with respect to that in the other phase, is, of course, determined by the relative positions of the pilot coils. With the second phase of the pen

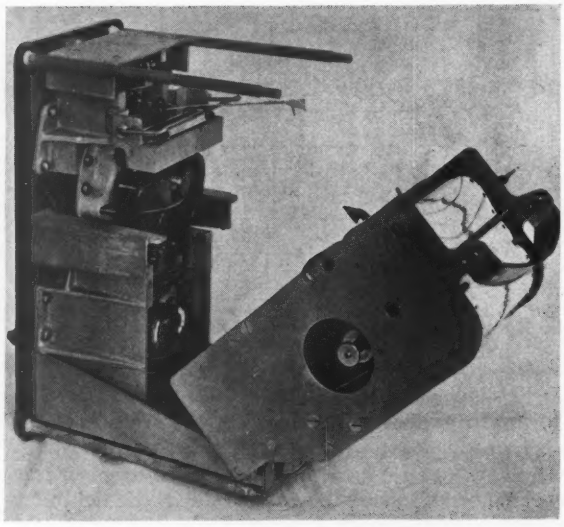


Fig. 4. The Westinghouse electronic recorder

driving motor connected to the amplifier output, the motor will turn in a clockwise or counterclockwise direction at a speed proportional to the difference in pilot coil positions. This results in a proportionate response action of the pen motor.

Thus, it will be obvious that the pen pilot element will always tend to set itself in a position to correspond with that of the primary pilot element. The pen motor turns in one direction or the other until the difference in pilot voltages is zero. It is, therefore, a "null" method. Since the speed of response is a function of the difference in pilot coil positions, antihunting or special damping devices are unnecessary.

This instrument will record d.c. millivolts and microamperes at energy levels of 4 or 5 microwatts. The torque of the recorder is 5 to 10 times that of a conventional direct acting recorder and this greater torque is attained without increasing the weight or inertia of the pen driving mechanism, in fact the motor element is lighter than a direct acting element. The amplifier is, of course, a high vacuum tube amplifier of more or less standard design.

The Photoelectric Recorder

Now, we will direct our attention to another recorder which involves a photoelectric system. Like the unit described above, this photoelectric recorder which is that developed by the General Electric Co. combines all the advantages of direct-acting recorders with those of the most sensitive indicating instruments.

This is accomplished by providing a separately excited recording element to do the actual work of making the record. A sensitive indicating instrument controls the position of the recording element so that the record obtained represents the readings of this basic instrument. The loss in the sensitive instrument is only the power required from the measured circuit.

Unlike the first recorder described, the sensitive indicating instrument in this photoelectric recorder is electrically isolated from the recording element. The link between the basic and recording elements consists of a combined optical system and photoelectric circuit. The basic element itself rotates a galvanometer mirror through an angle corresponding to its readings and can be even more sensitive than the usual indicating instrument with a pointer. On the other hand, the recording element may readily possess as much torque and be as heavy and sturdy as desired without affecting the basic element or measured circuit in any way. As will be shown, the two elements are entirely isolated except for an optical link.

The basic instrument carries a galvanometer mirror, the deflection of this mirror in response to the measured quantity is the only mechanical work the instrument is required to perform. By means of an optical system and an electron tube circuit, a high torque recording element is actuated so that it follows the basic instrument and records its readings. The power necessary to operate the recording element and the other parts of the recorder is obtained from an auxiliary source so that the losses in the basic instrument are the only losses which the measured circuit is required to supply. Thus the fundamental advantage of the photoelectric recorder exists in its ability to utilize the most sensitive indicating instruments and galvanometers as recorders with direct acting recorders of conventional design.

Regardless of the type of basic instrument used, whether a galvanometer or an indicator, it is arranged to deflect a small mirror in front of the lamp-housing lens tube.

There are two mirrors, the one just referred to attached to the basic instrument, the other attached to the recording element. A diagram of the complete optical system is shown in Fig. 6. The optical system is located between the two mirrors.

The light from the lamp after passing through a condensing lens falls on the basic element mirror from which it is reflected to some point on the curved reflector depending upon the reading of the basic instrument. From the curved reflector, the light is

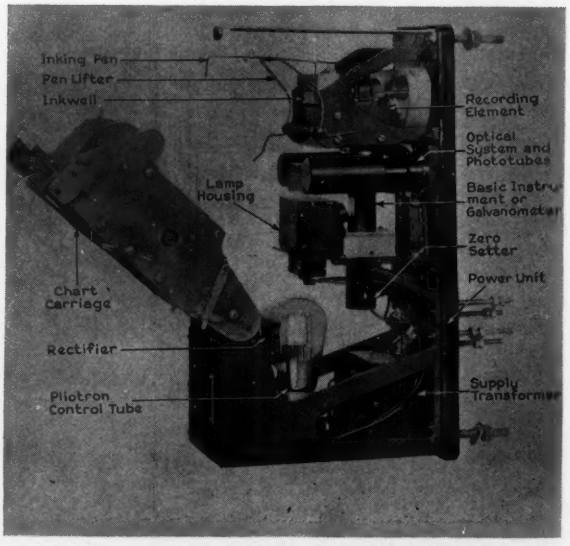


Fig. 5. The General Electric photoelectric recorder

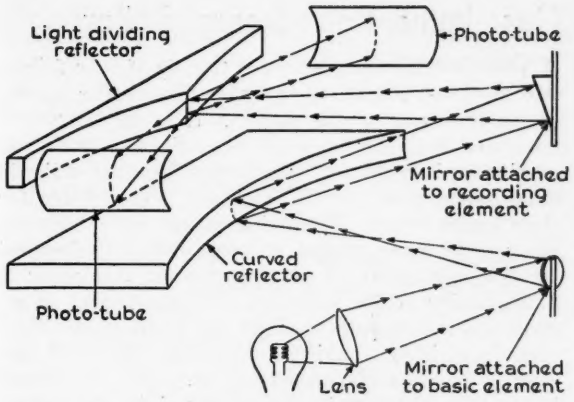


Fig. 6. The complete optical system of the photoelectric recorder

reflected into the recording element mirror and from there to the light dividing reflector and then to the two phototubes. It is in the optical system that the light-ray connection between basic and recording elements ties up with the photoelectric circuit to cause the proper functioning of the recording element. The optical system accomplishes this by allowing an excess of light to fall upon one or the other of the phototubes when the recording and basic elements are not exactly in line. If the recording element is too far down scale, more light falls upon the phototube to the left and if it is too far up the scale, more light falls on the phototube to the right. When the recording and basic instrument elements are exactly in line, the light ray divides evenly between the two phototubes as shown in Fig. 7. In this illustration the mirrors are shown offset so that the various angles of reflection can be traced. It will be noticed that regardless of the position of the basic instrument mirror, the

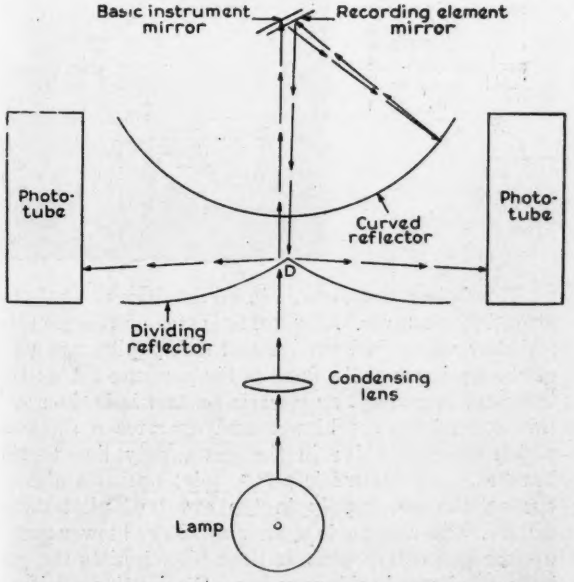


Fig. 7. Diagram of the optical system of the photoelectric recorder showing the division of light between the two phototubes

light ray will come straight out toward "D" when the recording and basic instrument mirrors are parallel.

The photoelectric circuit through which the optical system operates the recording element is shown in Fig. 8. This circuit is composed of two 3 element vacuum tubes. One of these tubes operates as a rectifier with the grid permanently connected to its filament and the other operates as a control tube. The rectifier passes a constant half wave direct current through the recording element in the direction necessary to force the recording pen down scale. The

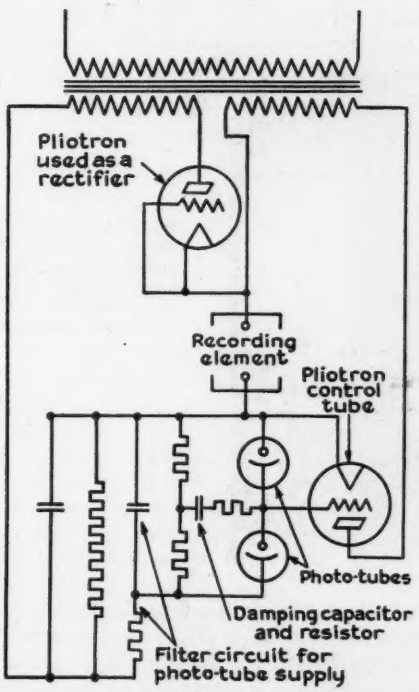


Fig. 8. Schematic diagram of connections of the photoelectric recorder

control tube passes a similar current through the recording element in the direction necessary to force the pen up scale. In the latter case the magnitude of the tube current is determined by its grid potential, which in turn is controlled by the potential controlled by the phototubes.

If the optical system indicates that the recording element should move down scale, more light is caused to fall on the lower phototube in Fig. 8 which swings the grid voltage in the negative direction. This decreases the current through the control tube, allowing the rectifier current to come into effect and move the recording element in that direction. If it is necessary to move the recording element up scale, the opposite action takes place. When the recording pen is in the correct position, the phototubes adjust the current in the control tube so that it balances the current from the rectifier and there is no motion of the recording element.

In addition to supplying the current necessary to

operate the recording element in the down-scale direction, the rectifier tube also provides a source of voltage to operate the phototubes. This voltage, as obtained across the series resistance, is of course, half-wave direct current. The resulting pulsating potential drop is filtered before application to the phototubes by means of the capacitance and series resistance which is connected across the resistor.

It will be quite obvious that the sensitivity of this recorder is dependent only upon the sensitivity of the basic element. Rapidity of response is usually governed by the period of the basic element, although in some isolated cases the period of the recording element may become the limiting factor.

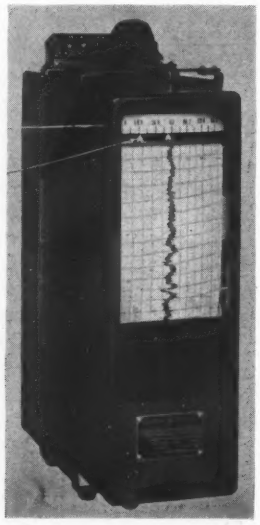


Fig. 9. The General Electric Photoelectric Recorder, complete in case. It resembles the ordinary direct acting recorder but is often a million times more sensitive.

The highest sensitivities first obtained in frequency records with this recorder were greater than are justified by present central station practice. In frequency recorders a scale range of from one to two cycles has been found quite practicable. Voltage recording has been accurately accomplished with a chart-scale range of 4 or 5 v. on a 115 v. circuit.

Perhaps the greatest advance, however, has been obtained in low-reading microammeters. Several recording microammeters have been constructed with a full scale current of less than one microampere. At full scale such recorders draw less than 0.001 microwatt from their measured circuit. Their operation is better in many respects than direct acting recorders requiring many millions of times more power.

A knowledge of the action and sensitivity of this recorder gives one an appreciation of the marvelous power of the electron tube in extending the field of action of existing instruments. Taking no power at all from the basic measuring instrument, it nevertheless multiplies the power of the basic instrument millions and millions of times. In the case of the recorder the object is the movement of a recording pen over a moving chart, but by the use of other amplifier tubes, the basic element could just as readily cause the movement of a steel girder weighing many tons if that should ever prove necessary.

Gas Immersion Steam Boiler

DESIGNED to eliminate the trouble of tube failure due to corrosion a new type of gas boiler has recently been put on the market. It is an immersion, horizontal fire tube boiler gas fired and automatic and continuous in operation. Due to the fact that it lies in a horizontal position the tubes are under water for their entire length. The firing of the boiler employs the gas immersion heater principle and it is designed for both high and low steam pressures. According to J. B. Nealey of the American Gas Association an installation was recently made in the plant of the Moon Manufacturing Co., Chicago, for block testing and running a small turbo-generator set. This particular boiler is a 20-hp. unit, manufactured by the Sellers Engineering Co., Chicago, Ill., and the steam is used at 100 to 125 lb. pressure. It is 30 in. in diam. and 8 ft. long and is said to raise 100 lb. of steam pressure from cold in 12 to 15 min.

Heat is supplied through a series of tubes making two complete passes each and giving a total of 14 ft. of flue gas travel each. In this design the tubes are below the water level and therefore out of the region of corrosion. An 8 inch space is left between the bottom of the boiler and the lowest tubes for sediment collection.

Firing is accomplished by a battery of specially constructed immersion gas burners, each of which fires into the end of one tube. The first pass of the tubes are in the upper portion of the boiler and the return in the lower. A blower is employed to supply air for combustion which gives positive control over the gas-air mixture at the burners at all times.

New gas immersion boiler which attains a pressure of 100 lb. per sq. in. from "cold" in 12 or 15 min.

This boiler is automatic in all details and needs no attention whatever. An automatic steam pressure control, low water fuel cut off and safety pilot are part of the equipment. As soon as the pressure set on the indicator is reached an electric contact is broken and this stops both the blower and operates a solenoid which closes a valve in the gas supply line to the burners. The automatic safety pilot operates also to cut off the gas supply in the event of pilot flame failure. When steam is again needed the blower starts up, the gas valve opens and the pilot ignites the gas burners, always in this sequence. Combustion efficiency of 80 per cent at 100 lb. steam pressure is reported.

Metallic Vapor Lamps Well Rooted

Growth of Mercury and Sodium Lamp Installations Indicates Established Usage

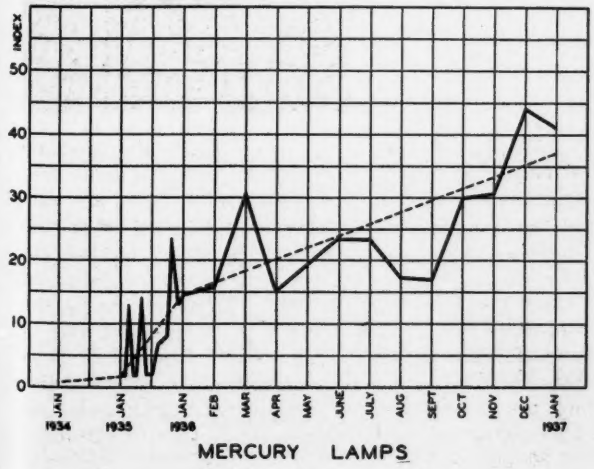
By SAMUEL G. HIBBEN

Director of Applied Lighting
Westinghouse Lamp Division
Bloomfield, N. J.

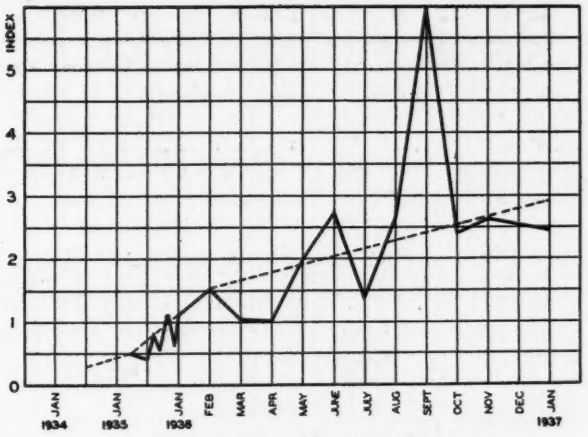
WHEN THE FIRST commercial installations of sodium and mercury (high intensity) lamps were made, early in 1934, there were no definite means of indicating the acceptability of these sources, and only rough predictions as to their growth and of their place in the lighting business. As in the case of any pioneering, certain mechanical and electrical difficulties had to be ironed out by practical experience, hence throughout 1934 and into 1935 these lamps were being introduced chiefly on the basis of trial installations and with more or less experimental designs of fixtures.

By the middle of 1935 it became increasingly evident that one or two commercial sizes of sodium lamps were sufficiently well standardized together with their operating accessories to justify large scale highway installations, and that the 400 watt size of mercury vapor lamp was acceptable for certain classes of industrial lighting. Nevertheless it was not until well into 1935 that any great assortment of reflectors and fittings were available, these chiefly for the mercury lamp, nor until about a year ago that added flexibility was made possible by the addition of the 250 and the 85 watt mercury lamps.

By the beginning of 1936 it became fairly evident that the mercury lamp was finding a definite and distinct place in industrial lighting especially in the high bay types of installations and where a large lumen output could well be utilized. The trend of acceptance became such that it now becomes possible to establish some predictions as to rate of growth of mercury lamp installations as depicted by the chart of Figure 1 (Mercury Lamps). In this figure, taking the vertical scale as an index of growth of sales, it may be noted that from the beginning to the end of 1936, the monthly sales more than doubled.



MERCURY LAMPS



SODIUM LAMPS

Of the three mercury lamp sizes commercially available, the 400 watt remains easily the foremost in popularity. The 250 watt size finds its greatest usefulness in the enclosing globe or diffusing glass fixtures when mixed with not less than equal wattage of Mazda incandescent lamps and chiefly for mounting heights on the order of 10 feet. Accessories for the so-called capillary type of concentrated source 85 watt lamp have not been sufficiently developed nor the usage sufficiently well established to predict exactly what this lamp's place in the field may be.

It may fairly well be assumed that during 1936 there were perhaps better than 35,000 new mercury lamp sockets placed in service which, added to an estimate of some 16,000 new sockets in 1935, would total something more than 50,000 mercury lamps in service at the beginning of 1937. There is no reason to expect other than a continuous rise in mercury lamp usage especially since the fields of color floodlighting and of street lighting are almost wholly undeveloped.

Since to date the sodium vapor lamps in this country have been limited to the two sizes namely, 6000 to 10,000 lumen and almost altogether to the field of highway lighting, one would expect a usage on the order of 10 per cent of that for mercury lamps, and a somewhat slower acceptance. Nevertheless the installations of sodium lamps for highway lighting have indicated good possibilities; suitable accessories are standardized and there is every indication of a steady although not spectacular growth as indicated by Figure 2. (Sodium Lamps). It has been estimated that some 2000 sodium lamp sockets went into service last year and something less than one half of that number during the preceding two years.

This progress may be compared with the usage of the mercury lamps for highway lighting in England, where some 1000 miles of highway are well illuminated with no fewer than 30,000 units.

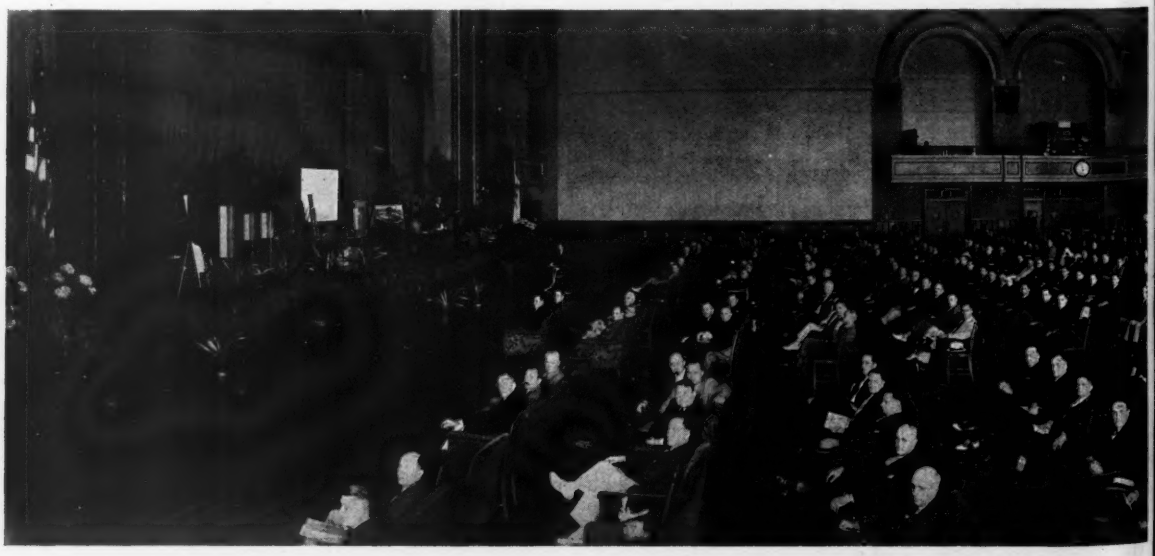
Residential Load of Growing Importance to Utilities

The significance of the steadily growing residential load was one of the most discussed topics at the sixth annual convention of the Edison Electric Institute at Atlantic City. Once a necessary evil, it may yet become the mainstay of the utilities source of revenue.

WHEN we stated in the June issue of Power Plant Engineering that the Electric Utility industry, today, had its feet squarely on the ground, we were not indulging in platitudes, we meant it, but if there had been even a question of a doubt in our minds about it, that question certainly would have been dispelled during our attendance at the Edison Electric Institute convention at Atlantic City during the week of June 6. For this convention, more, perhaps, than any other since the Institute's formation in 1933 brought out how solidly and how determinedly the Utilities are united in the effort to do a good job and to remove from the industry any stigma that may have become attached to it by the poor judgment and malpractices of a few manipulators in the past.

This convention, as were the others since the reorganization of the N. E. L. A. in 1933, was characterized by a strict adherance to business and to a sincere and honest effort to solve the problems that confront the industry. There was less emotional appeal than at some of the previous conventions and though it may have been only dormant there seemed to be less bitterness against government policies and practices. The emphasis was rather upon the economic problems confronting the industry and methods of solving these problems. Unlike a year ago, when loads everywhere were going up and power sales increasing, at the present time the load is down and revenues correspondingly low. The major problem, today, probably is the decreased revenue as compared to the cost of doing business. This situation is not unique with the electric utility industry, but it is more important in the utility industry than it is in other fields because of the fact that the utility business is a government regulated monopoly and that in most instances any increase in profits must come about largely as a consequence of more efficient operation. Increased load is, of course, another vital factor but unless operating costs can be lowered the effect of load building is considerably offset. Although actual generating costs have decreased remarkably during the lost two decades, the distribution and accounting costs, not to mention taxes, have increased enormously.

In the discussion of these problems at Atlantic City, a very significant factor was the emphasis that was placed upon the importance of the residential load. Time was when the residential load was regarded to some extent as a necessary evil, something akin to passenger traffic on the railroads, and which did not noticeably augment the profits. The commercial and



the industrial loads used to be the important factors on the balance sheet.

But the picture is changing and a number of speakers stressed the growing importance of the residential load. Davis De Bard of Stone and Webster for example was of the opinion that the very existence of the industry depended upon the proper solution of the residential load problem. Although residential service at the present time accounts for only 19.4 per cent of the total kilowatt hours sold, it is significant that this class of service has increased twelve fold in the last two decades as compared to only a four fold increase in the commercial and industrial classes of service. As pointed out by Harry A. Snow of the Detroit Edison Co. in his address entitled "Growth," the residential load is steady through booms and depressions. Sales of residential energy in 1932 and 1933, the two worst years of the depression, were larger than in April of 1929. More recently, Detroit Edison sales of residential energy in April, 1938, the sixth month of the often-alluded-to recession, were 15.2 per cent larger than in April of 1937.

Whereas the prospects for residential load building continue to be bright, the case for the industrial load is not so good. The industrial load was termed the temperamental prima donna of the electric industry. During the depression industrial power sales dropped from 42,970,860,000 kw-hr. in 1929 to 30,964,471,000 kw-hr. in 1932, nearly 28 per cent. In the case of Detroit Edison, Snow reported a decrease of 46 per cent for industrial sales in April, 1938, as compared to April, 1937.

Aside from the fluctuations due to general business the industrial load, it was pointed out, is subject to ever increasing competition. A most recent competitive influence in this field is the so-called "packaged Diesel" publicized and marketed by General Motors, and in the opinion of many at the convention, a serious factor in the small industrial power field. As pointed out by President Kellogg in referring to this development in his presidential address, while no significant change in the character of the Diesel engine itself has occurred, the introduction of a company with extensive sales and servicing facilities adds a new element in the competition.

One of the principal things the Utilities have suffered from in recent years has been a punitive attitude by the Federal Government. The removal of this threat will help greatly to enable the Utilities to perform efficiently their essential public service role in the life of the people; and Chairman Douglas' words and actions indicate a clear desire to do just that. The Utilities may be counted upon to meet this proffered cooperation in the same spirit that prompted it.

C. W. Kellogg, President E. E. I.

From the standpoint of smoothness, timing of events and perfection of appointments, this convention was unsurpassed. The spacious, comfortable Atlantic City auditorium provided a meeting hall such as can be matched by few places in the world. Its public address system was perfection itself and its mighty organ played sweet music in the interludes between sessions. Those few delegates who succumbed to the restful luxury of the deeply upholstered divans and dozed off during the sessions could do so with the full assurance that printed copies of the addresses they failed to hear would be available in the foyer at the end of the session.

The weather also was perfect. For practically two weeks preceding the convention it had rained in Atlantic City, but the morning of the "sixth" dawned bright and a spell of fine convention weather was ushered in. The water was cold, however, and few went in bathing. Atlantic City in fact was very quiet.

The attendance of 1260 odd members and guests was lower than last year, but in view of business conditions was not unexpected.

The program was simple and of wide general interest. There were four general sessions at which papers of diversified interest were presented. The convention banquet was held on Wednesday evening in the American ballroom of the Hotel Traymore, at

The spacious Atlantic City Auditorium provided a meeting hall such as can be equalled by few places in the world. Its public address system was perfection itself and its mighty organ played sweet music in the interlude between sessions.

which the Charles A. Coffin award was made. There were no simultaneous sessions and only a few committee meetings. The Charles A. Coffin award was given to the Cincinnati Gas and Electric Co.

All useless formalities and preliminaries, addresses of welcome and whatnot were dispensed with at the opening session Tuesday morning, June 7, and the meeting opened with the presentation of the President's address.

Cooperation of the S. E. C. Anticipated

While apprehension regarding the attitude of the Federal Government toward the utilities has by no means disappeared, it was noticeably less than in previous year, and President Kellogg's opening remarks on government coöperation were particularly encouraging. He pointed out that the year had witnessed the registration with the S. E. C. under the Public Utility Holding Co. Act of practically all such companies in this country. At the suggestion of Chairman Douglas of the Commission, a committee representing the principal holding companies has been set up to coöperate with the Commission in the study of possible reintegration of the existing utility groups and of the regulatory provision of the Holding Co. Act. Although it is too early for any tangible result to emerge from this coöperative effort, conferences have begun, and as Mr. Kellogg pointed out, the gesture itself should be of happy augury for the industry. One of the principal things the utilities have suffered from in recent years has been a punitive attitude by the Federal Government. The removal of this threat will help greatly to enable the utilities to perform efficiently their essential public service role in the life of the people; and Chairman Douglas' words and actions indicate a clear desire to do just that.

The outcome of the Electric Bond & Share Case was disappointing

The Electric Bond & Share decision, government competition, financing, farm electrification, residence wiring program and Diesel competition were briefly discussed by Mr. Kellogg. The Bond & Share case was, of course, history, but the outcome was disappointing and it was felt that the Government had not kept faith with the utilities in promising to offer an adequate test of the constitutionality of the Holding Co. Act.

Farm electrification, Mr. Kellogg reported, had made great strides. At present about 1,300,000 farms are taking service or about 20 per cent of the farms with occupied dwellings and 30 per cent of those with dwellings valued at $500 or more. This average farm electrification of 20 per cent, however, varies widely throughout the nation, from 95 per cent in the small densely populated state of Rhode Island and 90 per cent in California to only 2½ per cent in Mississippi and 3 to 4½ per cent in Arkansas and the Dakotas.

The problem of power sales and profits was discussed specifically in a paper by W. H. Sammis, vice-president of the Commonwealth and Southern Corporation. Increases in gross revenue no longer bring corresponding increases in net income and the earning power of invested capital is showing a steady decline. While much of this decline is the result of increased wages, taxes and other costs, other factors enter into the picture. A decade ago Mr. Sammis said, a considerable proportion of the sale of power came from the replacement of isolated power plants. The 1929 U. S. Census of manufacturers stated that 79 per cent of all motors in the country were served by purchased power. This indicates that a good job was done and undoubtedly if later figures were available the percentage would be higher. However, it is an ever-continuing job to keep industry using purchased power as the manufacturers of isolated plant equipment are actively promoting their products. While the efficiency of central station plants has steadily increased, the same is true of isolated plant equipment. Today the cost of operating an isolated steam plant is 30 to 40 per cent lower than in the early '20s. In the case of Diesels, while the improvement in economy has not been as great, the investment per kilowatt installed today is less than half of that of the early '20s. In this connection, Mr. Sammis pointed out the serious competition that may be expected from General Motors' entrance into the stationary Diesel field. While the electric industry need not fear their competition on an honest basis, nevertheless Diesel manufacturers are beginning to capitalize on the publicity which has been accorded the situation. As an example of the extremes which some manufacturers will go to get an initial plant in new territory, Mr. Sammis cited the following promises and guarantees in addition to the usual fuel oil guarantees as made to a particular customer: (a) Installation with no down payment to be made for a 90-day trial period at the engine company's expense. (b) Satisfaction is guaranteed and if there is any objectionable noise, odor or vibration, during the trial period, the engine will be removed at the engine company's expense. (c) The unit is guaranteed to operate during the trial period without the services of an engineer and, if an engineer is required even after the trial period, the customer may cancel the contract.

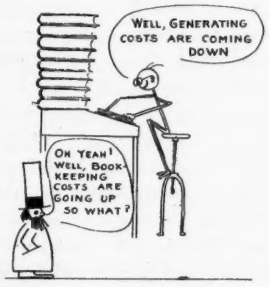
Public Relations are always important

And Mr. Sammis implied that any location is "new territory" for most of the 50 odd Diesel engine builders.

Other factors in the power sales picture that are becoming of increasing importance according to Mr.

Sammis are the use of electricity for cooking, air conditioning, better lighting and the new Chemurgic movement. The latter is based upon the concept that wealth can be created out of the soil which can be utilized by industry.

Aside from methods to meet competition and build new loads, Mr. Sammis urged attention to rate schedules. In view of the serious decline in industrial power sales, the rate schedules, he felt, should incorporate adequate charges to protect the investment needed to serve these customers. Also, he pointed out, in connection with oil engine competition, it is not unusual for customers to install a single



Of growing concern are the increased accounting costs

oil engine unit and retain a connection with the utility for breakdown service. Unless the rate schedules, rules and regulations are properly designed and applied, the utilities will find themselves aiding their competitors. All these factors Mr. Sammis pointed out in conclusion was making the matter of selling power a more and more specialized function.

Public Relations

Public relations and publicity matters were covered in three papers, one by H. S. Metcalfe, director of public relations of West Penn Power, another by J. E. Davidson of Nebraska Power and a third, representing an outside but allied field, by W. H. Harrison of the American Telephone and Telegraph Co.

Mr. Metcalfe cleverly told his story in terms of the five pebbles for David's sling which he used to lay Goliath low—a case of overcoming one set of ideas with another. American business, said Mr. Metcalfe, faces three Philistine conditions: unfriendly attitudes, the new era of questioning and the tyranny of words.

There are five stones for David's sling which can meet and overcome these conditions. They are: friendliness, logic and three kinds of facts—facts about the industry, facts about what people think, and facts about economics. Not only do individual utilities have to have these projectiles available, but each company needs a central firing control station to give David the proper corrections for range and deflections as required by modern gunnery.

While we cannot present the substance of Mr. Metcalfe's interesting address, his plea was, first, for a new evaluation of the obstacles which stand in the way of a more favorable public opinion for the electric utilities. Secondly, for the recognition and use of those forces, stones for David's sling, which can be of value in overcoming these obstacles. As a suggestion in meeting these problems, the author urged the centralizing of responsibilities for publicity and advertising in individual companies and further the creation of a national committee for the consideration of the advertising and publicity factors in public relations.

J. E. Davidson in his address "Ten Ways to Make Your Customers Like Your Company," called attention to the speed at which mass thinking changes these days and that this called for greater alertness on the part of the utility employees in maintaining contact with the minds of the customers.

Growth

One of the outstanding papers presented at the convention was the splendid analysis of the growth of the industry by Harry A. Snow, Controller of the Detroit Edison Co. Mr. Snow's address fairly bristled with interesting figures. In the last two decades from 1917 to 1937 electrical energy generated by the utilities has grown from 25,438,000,000 kw-hr. per year to 115,165,000,000 kw-hr. or more than fourfold. In 1937 three main classes of service took 91 per cent of the total output; residential service 19.4 per cent, commercial service 17.6 per cent and industrial service 54 per cent. The small remainder was used principally in street lighting and traction.

Residential service (including farms) has had the most rapid growth, increasing twelvefold in two decades. This increase in residential sales has come about from (1) an increase in the number of customers and (2) an increase in the consumption per customer.

In 1917 there were 5,810,300 residence customers in the United States and in 1937, 22,939,020. Meantime the population has grown from 102,172,845 to 129,257,000. Thus in 1917 one family in four was receiving electric service; in 1937 three families in four. There is therefore not much room left for growth by extending service to more families.

Growth was the subject of a talk by Harry Snow of Detroit Edison

Consumption of electricity per residence has increased from 275 kilowatt hours in 1917 to 839 in 1937. This type of growth, Mr. Snow pointed out, has by no means approached a natural limit. In the city of Winnipeg for example the average annual consumption in 1937 was 4,765 kw-hr. Rates in Winnipeg are low (0.827c per kw-hr.) so that electric energy is cheaper than fuel for cooking and water heating.

In an analysis of the energy used by various household appliances, Mr. Snow showed that three appliances, the water heater, the range and the refrigerator, account for 77 per cent of the total. The problem for growth of residential service therefore is the problem of making available to everyone these three appliances. Strangely enough in this analysis, the electric clock with an annual consumption of 18 kw-hr. comes out ahead of the electric food mixer with only 10 kw-hr.

These figures are typical of countless others presented in Mr. Snow's paper. This paper was as thorough an analysis of the utility growth questions as has been made anywhere and his figures no doubt will be quoted for years to come. Regarding the effect of rate reductions on residential load growth, Mr. Snow was inclined to doubt that it had material effect. The cost of electricity is so small a part of the cost of living that small changes in the cost of electricity probably exercise negligible effects on the habits of life.

Cost of Plant

The paper on the cost of plant presented by A. H. Kehoe of the Consolidated Edison Co. of New York contained much of direct interest to engineers and executives alike. Beginning with a consideration of investment in plant compared to revenue, Mr. Kehoe said that with a present plant investment of approximately 13 billion dollars and a gross revenue of slightly more than 2 billion dollars per year, the resulting return on investment can be subject to only very minor variations if the business is to remain in a healthy state and be able to finance betterments and expansion of service.

Plant investment costs, Mr. Kehoe showed, varied with trends. Such trends have been particularly noticeable since 1930, when with capacity of about 32 million kilowatts the total investment in plant averaged $362 per kw-hr. of net generating capacity. A maximum of over $373 was reached in 1934; and in 1937, with 35 million kilowatts of station capacity, investment decreased to 369 per kw.

From the analysis of cost of the various divisions of plant, Mr. Kehoe indicated that it now seems reasonable to expect that the unit cost of total plant investment will be reduced if additions in capacity are required under circumstances existing at the present time. Average generating costs per kilowatt of installed capacity including both steam and hydro have been decreasing since about the middle of the 1920 decade. They were about $162 per kw. in 1920, $141 in 1930 and $138 in 1937. Steam stations averaged $125 in 1920 and since 1930 the cost has been from $5 to $7 less than in 1920. With the large number of topping turbines which are certain to be installed as soon as increased capacity is required, the average cost of generating stations will be further reduced.

Distribution costs, as Mr. Kehoe pointed out, have increased rather than decreased. In 1920 the average cost of distribution facilities was $57 per kw. of installed generating capacity. In 1930 it was $82 while in 1937 a further increase to $89 was experienced. While distribution costs had gone up, Mr. Kehoe stated that he did not believe that the trend in distribution cost was explosive in character. They did, however, require closed supervision.

Summing up his paper, Mr. Kehoe was of the opinion that when the next period of great expansion comes along, the cost of adding plant capacity equal in amount to that which we have today should be substantially less than the total cost of providing the plant we now have, possibly a third less.

The papers thus far referred to were all presented at the two sessions on Tuesday. The session on Wednesday morning was given over to a variety of subjects. There were two addresses describing the two World's Fairs to be held next year, the one on the New York World's Fair, presented by Colonel John P. Hogan, Chief Engineer of the N. Y. Fair, and the other one on the Golden Gate International Exposition by Colonel J. Franklin Bell, Executive Vice-President of the San Francisco Fair.

The session concluded with a most interesting demonstration by Ward Harrison of the Nela Park Laboratories of the new fluorescent lighting units.

The convention came to an end Thursday morning with the announcement and presentation of various prize awards and two addresses, one "The Challenge to American Business Leadership" by Dr. Virgil Jordan, of the National Industrial Conference Board and another, "Capitalism Without Capital," by Dr. W. W. Cumberland, of Wellington & Co. Both of these papers discussed critically the social and economic conditions existing today. Dr. Jordan emphasized the fact that in the quarter of a century behind us this country and most of the world has been involved in a progressive process of economic, political and social deterioration and that this will continue toward its inevitable end until enough people of intelligence, integrity, and courage decide for themselves what is worth trying to save in our civilization and resolutely set about saving it at whatever personal sacrifice may be necessary.

To forestall this, Dr. Jordan challenged American business to mobilize itself and proceed to this definite task in the traditional and sound American way, by industrial and local organization along state lines under the inspiration and supervision of a national reconstruction council of business leaders.

Portland General Electric Co. has been authorized to merge five of its wholly-owned subsidiaries, Yamhill Electric Co., Mollala Electric Co., Electric Supplies and Contracting Co., Electric Appliance and Construction Co. and Clackamas Power and Irrigation Co. by transferring all their assets to the Portland General Electric Co. which is to assume all their liabilities and cancel all their capital stock.

Upon consummation of the merger, book value of the Portland General Electric Co.'s utility plant will be increased from $56,656,884.11, as of October 31, 1937, to $58,039,405.48; subject to such further segregation of intangible items from the company's electric plant account as may hereafter appear when its books have been set up in accordance with the Federal Power Commission's uniform system of accounts.

As the properties involved are interconnected, and merger, it is stated, will result in minor operating economies and will be an influence toward the reduction of rates; there will be no adverse effect upon consumers or security holders; and applicant's corporate structure and operations will be simplified and strengthened.

Oil Free Compressed Air

Reciprocating compressors operated without cylinder lubrication developed by Sulzer Bros. for special application. Power saving over rotary compressors justifies the additional cost

REMOVAL of oil from compressed air to give a standard of purity demanded by certain industrial applications is practically impossible. To take care of such conditions and requirements, Sulzer Bros. of Switzerland have recently developed a reciprocating compressor designed for operation without cylinder lubrication. A design of this type requires workmanship of extraordinary precision and materials not heretofore available for this work although in the past steam engines have been operated without cylinder lubrication beyond that provided by moisture in the steam.

This compressor is of the vertical type with the piston rod and piston carefully balanced to eliminate lateral deflection. The piston rod is fitted with a cross head and the piston is guided by a vertical tail rod. By this arrangement the distance between the piston and the cylinder can be reduced to a minimum without danger of contact. In addition the piston is covered with antifriction metal in which circular grooves are cut to form a labyrinth to retard the passage or leakage of air. The tightness is said to be equal to that obtained with piston rings.

Stuffing box lubrication has been eliminated by using a compressed carbon made up of annular segments shaped so that there is no direct rubbing contact with the rod. Tightness, as in the cylinder, being obtained by the throttling effect.

The cylinder itself is made of special rustless cast-iron to eliminate any possibility of rust from moisture contained in the air.

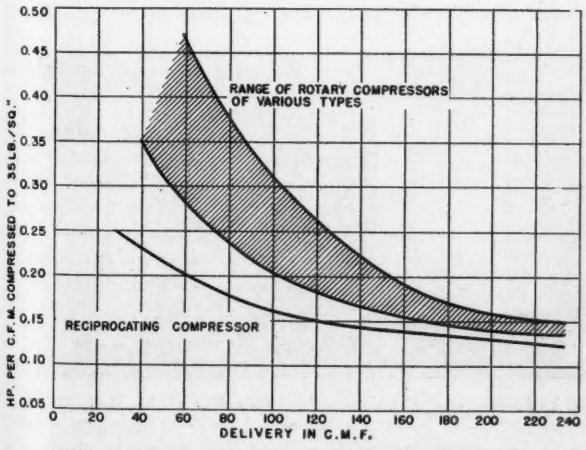


Fig. 1. Average power required by a reciprocating air compressor is considerably below the power requirements of the rotary type

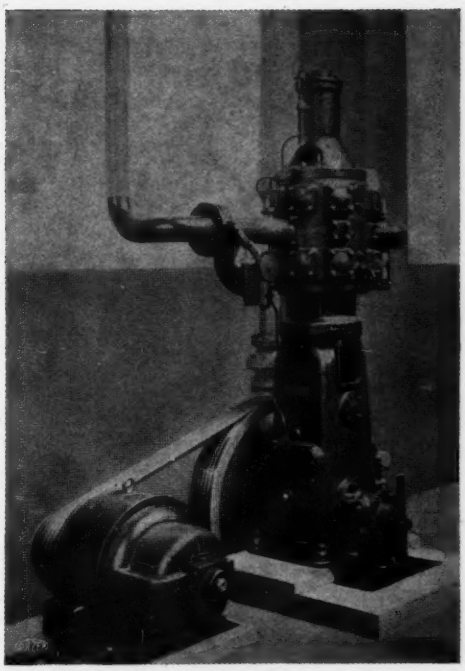


Fig. 2. Sulzer reciprocating compressor which operates without cylinder lubrication. The volume control in the suction line is visible just to the left of the compressor cylinder

For the crankshaft and tail rod the lubricating systems are designed so that the oil cannot possibly find its way into the cylinder. The crankcase, the lower part of which forms a sump for the circulating oil, is closed at the top above the crosshead by a stuffing box as is the lower end of the tail rod.

Although a compressor of this type is slightly more expensive than a normal compressor with lubricated cylinder, the power savings over a rotary compressor which would be used to obtain the same compression ratio is considerable, as shown by Fig. 1. Although the energy at full load may be only 8 per cent in favor of the reciprocating machine, the energy requirement at low load or average load may be well over 50 per cent.

Considering the method of regulation used in compressors of this type, that is at full load or completely unloaded, the average daily load even for heavy operation will probably not run over about 50 per cent of capacity so that a reciprocating compressor will show a saving of about one-half over a rotary type.

Figure 2 shows a non-lubricated compressor designed for about 235 c.f.m. and installed in a Swiss brewery. This photograph also shows the regulating device which consists of a butterfly valve in the suction pipe, a servomotor operated by compressed air and a control valve. The control valve actuated by air pressure in the receiver operates to close the butterfly valve in the suction line when pressure reaches the desired value. The compressor then operates at no load until the receiver pressure drops and the control valve then opens the butterfly valve a definite amount. Air from the outside is drawn through a filter to remove dust before it enters the compressor.

Pipe Welding Costs and Data

Many Advantages of Welding Piping Obtained by Following Simple Procedure

By A. F. Davis, Vice President

The Lincoln Electric Co.
Cleveland, Ohio

AMONG the many different applications of electric welding in which the process will save time and money for the user, there is one in which the process is particularly effective. This in piping work, both in maintenance of existing systems and in erection of new ones. Plant operating and maintenance officials who have had experience with electric welding in piping work are familiar with the many advantages both in economy and convenience of the process. Countless systems, welded electrically, include lines operating at 1000 deg. F. temperature and 1200 lb. pressure.

Typical examples of arc welded piping are shown in the accompanying illustrations. Figures 2, 3, and 4

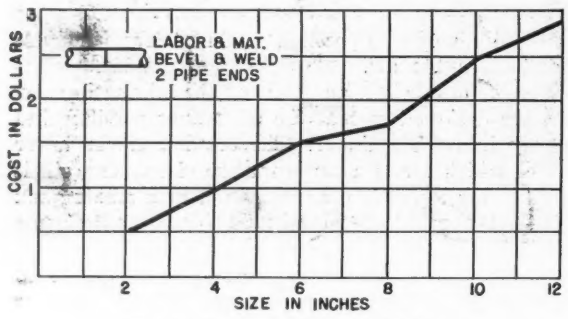


Fig. 1. Cost curve for welded joints

show arc welded piping of 10-in. diameter and 5/8-in. wall thickness arc welded to carry steam for a turbine. This system operates at 600 lb. per sq. in. pressure.

Drip piping, installed in a power plant by electric welding, is illustrated in Fig. 5. The advantages of arc welding can be appreciated by the number of threaded connections which were eliminated. This illustration also indicates that arc welding may be used as readily in connecting small pipe as large.

The ease with which arc welded pipe may be in-

Procedure data for welding butt joints in standard weight pipe in horizontal position

Size of Pipe		Beads or Passes	Electrode Size	Current Amps.	Min. Arc Volts	Actual Welding Time Min. Per Joint	Lbs. of Electrode per Joint
Dia.	Thickness						
Fig. 7 2"	.154"	1 2	1/8"	120 140	25	5.5	.35
Fig. 7 3"	.216"	1 2	1/8"	120 140	25	7.0	.44
Fig. 8 4"	.237"	1 2 3	1/8" 5/32" 5/32"	120 160	25	9.0	.64
Fig. 8 5"	.258"	1 2 3	1/8" 5/32" 5/32"	120 160	25	11.3	.81
Fig. 8 6"	.280"	1 2 3	1/8" 5/32" 5/32"	120 160	25	13.5	.96
Fig. 8 8"	.322"	1 2 3	5/32"	150 170	25	17.8	1.33
Fig. 9 10"	.365"	1 2 3 4	5/32"	150 170	25	22.0	1.65
Fig. 9 12"	.375"	1 2 3 4	5/32"	150 170	25	26.5	2.0
Fig. 9 14"	.375"	1 2 3 4	5/32"	150 170	25	31.3	2.3

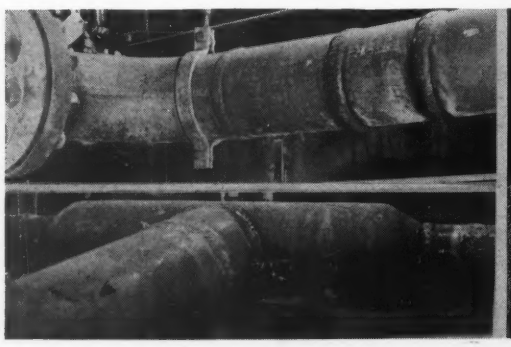


Fig. 2. A 10-inch diameter header piping for steam turbine. All joints are arc welded

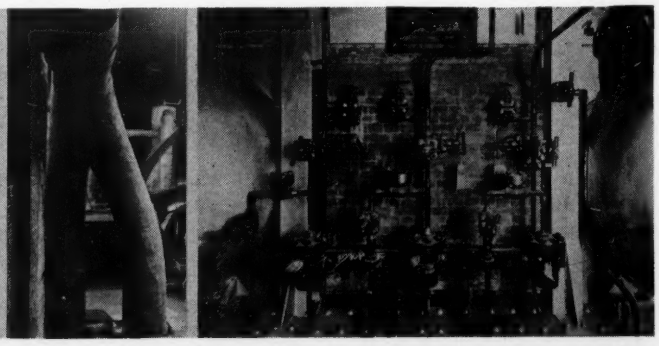


Fig. 3. Another view of the arc welded 10-inch steam header line for a turbine

Fig. 4. Close-up showing electric welds at Tee connection of steam line to turbine operating at pressure of 600 lb. per sq. in.

Fig. 5. Drip piping, installed in a power plant entirely by electric welding. Note the number of welded connections on small diameter pipe

sulated will be appreciated by reference to Fig. 6. The absence of any projections on the surface of the pipe makes the application of insulation a simple operation. The time for such work is approximately half that with conventional methods.

There is nothing complicated about welding pipe by the electric arc process. The work consists simply of following a certain procedure in preparing and welding the joints.

The accompanying illustrations, Figs. 7, 8, and 9 show preparation and welding of pipe in diameters from 2 in. to and including 14-in. These diagrammatic sketches, used in conjunction with the accompanying table, show the procedure for pipe welding.

As an example of how to use these sketches in con-

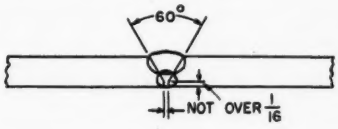


FIG. 7

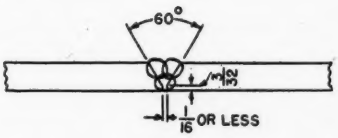


FIG. 8

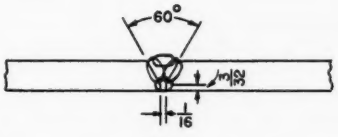


FIG. 9

Fig. 7. Sketch showing preparation and welding of joints in 2 and 3 inch diameter pipe

Fig. 8. Sketch showing preparation and welding of joints in pipe 4, 5, 6 and 8 inches in diameter

Fig. 9. Sketch showing preparation and welding of joints in 10-inch, 12-inch and 14-inch diameter pipe

junction with the table let us refer to Fig. 7. Note that this joint is used for connecting pipe of 2 or 3 in. diameter. In preparing the pipe for making this joint the spacing of the ends is not to exceed $\frac{1}{16}$ in. In regard to the bevel, this as indicated by the sketch is to be 60 deg. In making this bevel note that it is to stop $\frac{1}{16}$ in. in from the inner edge of the pipe. In the welding it will be noted that this is done in two passes each of which is made with 5/32 in. electrode. The recommended current range to be used for making the welds is 120 to 140 a. The minimum arc voltage is 25 v. The welding time for making the joint averages 5½ min. Usually 0.35 lb. of electrodes will be used. With the exception of the welding time and pounds of electrode used this data applies to either 2 or 3 in. pipe. In case of 3 in. diameter pipe the actual welding time per joint is 7 min. while the pounds of electrode used per joint is 0.44.

Using the sketches and table in this manner will provide correct procedure for welding pipe of the

Fig. 6. Applying insulation to arc welded piping is a much simpler operation than with other types of piping construction. Time is cut in half

Fig. 10. Ducts fabricated by arc welding carry hot air into boilers. Fabricated of 18-gage sheet metal

Fig. 11. Assortment of piping fabricated of 20-gage blue annealed sheet metal by electric welding

various diameters given in the table. It is to be noted that in welding 4, 5 and 6-in. pipe, one size electrode is used for the first bead and another for the second and third beads.

The advantages of electric welding in piping work are also available in the fabrication and installation of ducts. Regardless of the thickness of the metal, whether it be as light as 22-gage, electric welding will be found very economical. This is indicated by use of the process in many different plants. For example, the steel ducts shown in Fig. 10 were fabricated for conveying hot air into boilers at a temperature of 300 to 500 deg. F. The ducts illustrated are of 18-gage sheet metal and the fabricator reported a saving of 20 per cent in time and 30 per cent in cost.

Blue annealed 20-gage sheet metal arc welded into ducts for blowing blast gases into furnaces is shown in Fig. 11. The duct work operates at temperatures ranging from 650 to 780 degrees Fahrenheit.

Readers' Conference

Effects of Unburned Combustible

G. CAMPBELL KOHLER's analysis of the effect of unburned combustible on gas weight is quite correct on a *per pound of coal* basis but unfortunately he did not complete his analysis or it would have become quite apparent to him that unburned combustible has practically no effect on the total gas weight insofar as fan and design requirements are concerned. In other words, gas weight is a function of the fuel that is burned and is independent of the unburned combustible.

A non-mathematical analysis will show the falacy of considering carbon loss in the computation of gas weight requirements for a steam generator. Let us take the case of a chain grate or traveling grate type of stoker firing a boiler. The boiler is designed for a certain required maximum steam output which in turn requires a definite sensible heat input to the furnace. The sensible heat input is supplied by combustion of the coal which is fed to the stoker. The coal travels along the grate as it burns, the unburned portions dropping off the end of the stoker and sifting through the grates. This unburned portion is lost, and so, more coal must be fed to the stoker to supply the required sensible heat. If the coal (or carbon) doesn't burn it is the same as if it hadn't been supplied to the furnace, that is, it hasn't contributed to the sensible heat input required and therefore does not contribute to the combustible gases entering the boiler. If we can visualize a 100 per cent efficient stoker there would be no carbon loss and all the fuel is burned. Now if the carbon loss is "artificially" supplied by shovelling coal from the coal pile before it enters the stoker and is just thrown away, it is quite obvious that this will not in any way effect the gas weight leaving the steam generator. This is exactly what occurs except that instead of throwing the coal or carbon away before it enters the stoker, it is thrown away as it traverses along the stoker and does not enter into the combustion process.

This can be mathematically demonstrated from Mr. Kohler's coal and gas weight figures. Let us assume that we are designing a boiler and related equipment for a capacity of 60,000 lb. of steam per hr., the absorption per pound of steam is 1100, and the boiler exit temperature is 500 deg. F. Taking the gas weight computations given in Mr. Kohler's article and assuming a radiation and unaccounted for loss of 4 per cent, the following heat balance can be calculated with and without the unburned combustible loss:

I. CARBON LOSS CONSIDERED

1. Dry gas loss $\dfrac{0.24\ (500 - 80)\ 11.038}{11{,}745} = 9.47\%$

2. Loss due to hydrogen and moisture in fuel $0.48\ (500 - 80) = 202$
   $202 + 1040 = 1242$
   $0.311 \times 1242 \div 11{,}745 = 3.31\%$

3. Loss due to moisture in air
   $\dfrac{0.48\ (500 - 80)\ 0.137}{11{,}745} = 2.36\%$

4. Carbon loss 10.00%
5. Radiation and unaccounted for loss.... 4.00%

Total losses 29.14%
Efficiency 70.86%

Required input per hr. $\dfrac{60{,}000 \times 1100}{0.7086} = 93{,}300{,}000$ B.t.u.

Weight gas, leaving the boiler

$$\frac{93{,}300{,}000 \times 11.486}{11{,}745} = 91{,}100 \text{ lb. per hr.}$$

II. CARBON LOSS NEGLECTED

1. Dry gas loss $\dfrac{0.24\ (500 - 80)\ 12.175}{11{,}745} = 10.45\%$

2. Loss due to hydrogen and moisture in fuel $0.48\ (500 - 80) = 202$
   $202 + 1040 = 1242$

   $\dfrac{0.311 \times 1242}{11{,}745} = 3.31\%$

3. Loss due to moisture in air
   $\dfrac{0.48\ (500 - 80)\ 151}{11{,}745} = 2.59\%$

4. Carbon loss ..... = 0.00%
5. Radiation and unaccounted for loss.... = 4.00%

Total losses 10.35%
Efficiency 79.65%

Input to furnace

$$\frac{60{,}000 \times 1100}{79.65} = 83{,}000{,}000 \text{ B.t.u. per hr.}$$

Weight gas leaving the boiler

$$\frac{83{,}000{,}000 \times 12.637}{11{,}745} = 90{,}000 \text{ lb. per hr.}$$

The difference in gas weights, it will be noted, is negligible, and is due to the moisture in the coal which remains in the flue gas when the carbon is lost.

The gas weights listed in Table II of Mr. Kohler's article evidently have not been calculated on the basis that without the carbon loss, though the gas weight per pound of coal is higher, the input required is lower because the efficiency is higher. This factor is included in the gas weights calculated above as will be noted. Regarding the example given by Mr. Kohler about the Prominent Fan Manufacturer and the boiler manufacturer, I can only say that one of them made the same error that was pointed out above.

Brooklyn, N. Y. ADOLPH JOHNSON.

Steam Requirements of a Heating System

ESTIMATING the steam requirements of a heating system is a rather haphazard proceeding unless some reasonable basis for the estimate can be established.

Occasionally some particular feature of the system might suggest a method that would tend to give results with a minimum of inaccuracy.

The heating system of an office building was normally supplied by the exhaust from one or more engine-generator units, and when the supply of exhaust was insufficient for the demand, live steam was admitted through a reducing valve to make up the deficiency. Certain changes and additions made it desirable to have some definite idea as to the steam requirements of this system, and since no flow meters were installed, any such knowledge must be based on estimates.

In this particular building the heating system was kept in operation 24 hr. daily, and the electric load characteristics were such that it was at a minimum during the night, rose sharply during the early morning hours, stayed at a fairly constant maximum value during the day and after business hours gradually decreased again to a minimum; normally there was a surplus of exhaust steam during the day time and a deficiency at night. It is therefore apparent that there are two particular times in each 24 hr. when the supply of exhaust steam will exactly balance the (heating system) demand, in the early morning when the load is rising sharply and in the evening with the load diminishing gradually.

If the steam consumption of the engine generator units were known, it is obvious that the heating system demand would be known at that particular time when a balance existed between supply and demand.

It appeared that a reasonable basis had been established upon which an estimate could be made of the heating system requirements.

Steam consumption curves for the various generator units were plotted; curve A being for a 300-kw.

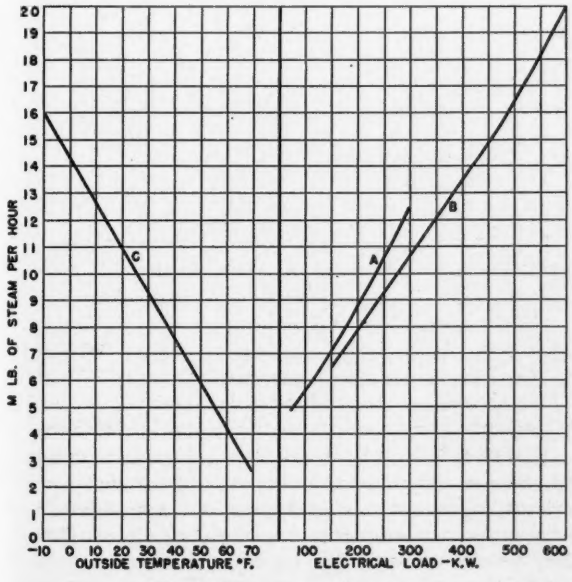


Fig. 1. Steam consumption curves

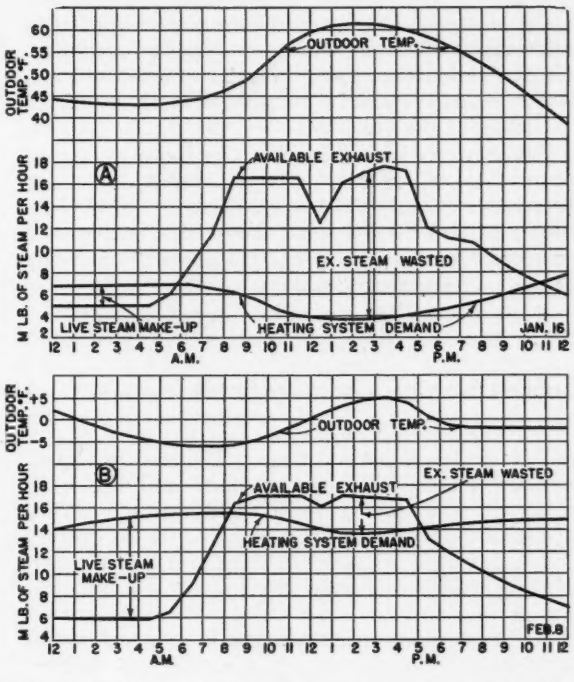


Fig. 2. Records of outdoor temperatures, steam demand for heating and exhaust steam available during two winter days

4-valve unit and curve B for a 600-kw. unaflow unit; these curves represent guaranteed steam consumption of these units when new and as only 85 or 90 per cent of the heat in the entering steam is available in the exhaust, and it is to be expected that there would be an increase of 10 to 15 per cent in steam consumption over the original guarantee, the curves were taken as representing the amount of exhaust available from the units.

During the evening hours with the electrical load diminishing gradually a close watch was kept on the heating system pressure, and when it appeared that a balance existed between the exhaust steam supply and the heating system demand, the electrical load and the outside temperature were recorded and by referring to curves A and B it became possible to know steam requirements of the heating system at this particular time.

A large number of readings were taken in the above manner and with the data so collected, curve C was plotted showing steam requirements of the heating system at various outside temperatures. It will be noted that the curve indicates a steam consumption of 2500 lb. per hour when the outdoor temperature is 70 deg., theoretically the steam requirements for heating become zero when the outdoor temperature becomes about 67 degrees; this can be accounted for from the fact that there would always be a surplus of exhaust steam and it is not advisable to shut down the heating system for short periods when the temperature goes above 70 deg., the room occupants will either shut off individual radiators or open windows to suit their own personal desires; the amount of steam condensed in the mains, risers and hall way radiators would then account for this amount.

It is not claimed that the above method will give results that are 100 per cent accurate or that it is applicable in all cases, but when conditions are favorable it is better than trying to make an estimate based on the amount of radiation installed or on the predicted heat losses of the building.

Subsequently with the aid of the above mentioned curves, the enclosed charts were made showing amount of available exhaust and heating demand over a 24-hr. period, as also the surplus exhaust that was wasted during one part of the day and the amount of make-up required during the remainder.

Rochester, N. Y. JULIUS BRODSKY.

Comparison of Viscosity Scales

IN CONNECTION with the use of heavy fuel oil, viscosity is a very important factor. The standard specifications give the viscosities of No. 5 and No. 6 oils at 122 deg. F. in Saybolt Furol (SSF) units, but when we discuss the lower viscosities required for satisfactory atomization, it is common practice to refer to the Saybolt Universal (SSU) scale, although sometimes Engler is used.

Although charts and tables are in existence by the use of which comparison can be made between the SSF and SSU scales, it is not always easy to find them, indeed, it is somewhat surprising that they so seldom appear in literature dealing with oil burning.

If we ask, what is the relationship between these two scales, we are likely to get the answer that there is no fixed relationship, which is literally true, but like many literal truths is somewhat misleading, as a comparison of the approximate figures in the accompanying table will show.

Approximate Relation of Viscosimeter Readings Between Seconds Saybolt Universal and Seconds Saybolt Furol

SSU	SSF	SSU	SSF	SSU	SSF
100	15	300	32	1000	101
120	16	400	41	2000	200
140	18	500	51	3000	300
150	20	600	61	4000	400
180	22	700	71	5000	500
200	24	800	81		
250	28	900	91		

It will be seen that between 400 and 5000 SSU, the ratio with the Furol scale is nearly constant at ten to one, and if we assume that at 300 SSU it is still ten to one, and at 100 SSU it is 6½ to one, we shall by interpolating, be able to estimate with a fair degree of accuracy, the intermediate ratios. For instance, we should find that the ratio for 200 SSU would be 8¼ to one, which would give over 23, for the SSF viscosity, which is very nearly right.

As a matter of fact, it is seldom that we require to know the exact relationship between the two scales, which perhaps explains why so many people appear to be satisfied with the statement that there is no fixed relationship between the two scales. On the other hand, it is not very satisfactory, when called upon to discuss viscosities in connection with oil burning, if you have to admit that you have no idea as to what the approximate relationship between the two scales really is.

In view of the fact that over a wide range, the approximate ratio of ten to one holds, and if, in connection with the rest of the scale we keep in mind the approximate ratios at 100 and 300 SSU, we can immediately estimate the approximate ratios for any intermediate viscosity, there does not seem to be much excuse for making a mystery of the problem.

In connection with this, it may be useful to remember that 15 SSF is equivalent to 3 deg. Engler, and 500 SSF to 145 deg. Engler, which gives ratios of five to one, to nearly 3½ to one, providing a rough idea of the comparative values of these scales also.

Bloomfield, N. J. JAMES O. G. GIBBONS.

Dresden Station

DUE to a misunderstanding, the name of the author of the article Dresden Station, which began on page 358 of the June, 1938, issue of POWER PLANT ENGINEERING, was omitted. This article was written by H. J. Vetlesen of the Engineering Department of the Utilities Management Corp., Reading, Pa.

Gas Engines for Power Generation

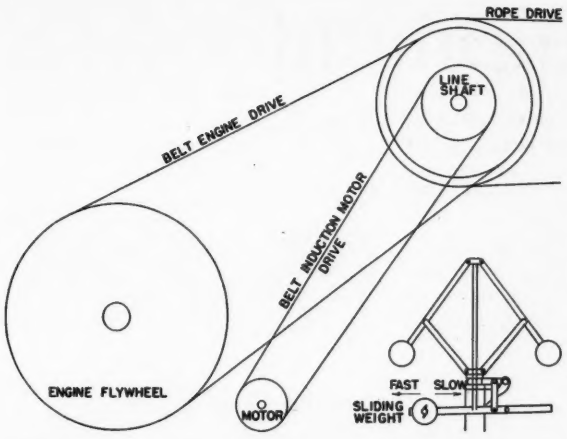
IN THE March issue, page 178, an article by Ralph S. Wenner deals with the operation of a gas engine in connection with an induction motor connected to the public utility lines and states that application has been made for a patent on the use of the induction motor in that capacity. This method of using an induction motor was used by others and myself as far back as 1915 in connection with a steam engine. As I understand the patent law, nothing is patentable that has been in public use for 2 yr. and if I am right, the engineering profession is free to use the above hook-up without fee to anyone.

In the installation I mentioned, a steam engine with a normal rating of about 125 hp. was operated in connection with a 25 hp. motor. Both were belted to a countershaft which was extended to drive a polishing, buffing and grinding shop by means of a rope drive to the main building. At load of about 125 or less, the motor was not electrically connected while at loads of 150 hp. the motor was connected and fully loaded. At loads of around 100 hp. the motor was generating full current and transmitting it to the line.

The method of operation followed was to bring the engine up to full speed before throwing in the motor switch and the motor was always disconnected from the line before stopping the engine. Current or power taken from, or, returned to, the lines was controlled by sliding the weight on the governor as shown in Sketch B. This method of operation is not, of course, any advantage if the public utility service is provided with a ratchet meter.

South Hadley Falls, Mass. GEO. C. WINTERBOTTOM.

EDITOR'S NOTE. Use of an induction motor in the manner described by Mr. Winterbottom, while perhaps not common, was known and apparently in more or less widespread use in the early days. From other sources we have since learned of such an installation that caused trouble to a utility as early as 1910.



Arrangement of the steam engine motor and detailed arrangement of sliding weight on the governor, which controlled the current used by, or, supplied from, the induction machine. When the engine operated at the lower than synchronous speed, the induction machine operated as a motor. At higher than synchronous speed the induction motor acted as a generator

One objection to the practice, from the utility standpoint, is indicated in the last sentence of Mr. Winterbottom's letter.

If the meter is not equipped with a ratchet, reversing the current flow runs the meter backward and this is in effect a power interchange between the industrial and utility on a one to one basis. Detection of the practice may be difficult and in the case mentioned, was discovered after the engineer became over-ambitious and not only cancelled the entire month's power usage but ran up a considerable credit.

Another valid objection that has been raised to parallel operation is that a line supposedly dead may be energized from the industrial plant and thus constitute a real hazard to employees working on the line. While parallel operation of industrial and utility plants is not unknown, it is still frowned upon and limited to larger sized industrial plants.

The patent application referred to by Mr. Wenner has been acted upon and patent No. 2,096,289 was issued Oct. 19, 1937, to Professor Delmos M. Palmer of the University of Toledo. One-third is assigned to R. S. Wenner and one-third to J. T. McMahon. This patent does not, however, refer to the use of an induction motor as a generator but to a combination of equipment or driving arrangement. There are two claims. The first covers:

"A driving arrangement for a system having a mechanical and electrical load including, an induction machine mechanically coupled to the mechanical load and electrically coupled to the electrical load, an alternating current supply line connected to said induction machine and said electrical load, a mechanical prime mover adapted to drive said mechanical load and connected to drive said mechanical induction machine above its synchronous speed and thereby operate the same as a generator to absorb said electrical load and control means for said mechanical prime mover interlocked with said alternating current supply line, operable to shut down said prime mover in event of failure of said alternating current supply."

The second claim refers specifically to the use of an internal combustion engine and is as follows: "A driving arrangement for a system having a mechanical and electrical load including, an induction machine mechanically coupled to the mechanical load and electrically coupled to the electrical load, an alternating current supply line connected to said induction machine and said electrical load, and an internal combustion engine delivering a power output greater than said induction machine and adapted to drive said mechanical load and to drive said induction machine above its synchronous speed and thereby operate the same as a generator to absorb said electrical load."

In a letter Mr. Wenner said: "You will note that this claim does not cover the use of an internal combustion engine driving an induction generator where the mechanical load is absent, nor does it cover the use of a steam engine to a combination mechanical and electrical load.

"I hardly feel that my own opinion as to the validity of this patent would be worth very much, but it is my understanding that in the opinion of competent patent attorneys the patent is a valid one."

Due to the intricacies of patent law, we will make no comment on the validity of the patent, nor venture an opinion as to the meaning of either claim. Two other paragraphs of Mr. Wenner's letter are, however, of interest in connection with the practical application of this driving arrangement and the objections mentioned earlier.

"Concerning the objection to the practice, from the utility standpoint, covering the probability of reversal of power flow; we have arranged to prevent this through the development of a load governor which will adjust the speed of the engine to the fluctuation of the customer's load. This governor is instantaneous in action and our tests to date have shown it to be very reliable. We are able to set the minimum amount of power to be taken for the utility lines at any predetermined point and as a consequence no pump back results.

"Concerning the other objection, I wish to point out that inasmuch as the induction motor acting as a generator is dependent upon the utility line voltage for excitation, it is impossible that a condition such as described can occur. If the supply line is dead the induction generator is also dead. It is for this very reason that we claim this method of parallel operation to be entirely safe and unobjectionable. The hazardous conditions which admittedly are present when a synchronous generator parallels the line are completely eliminated through the use of this plan."

THAT AUTOS and airplanes will not use Diesel engines, except experimentally, for a considerable time ahead is the opinion expressed by Dr. D. P. Barnard chief of the Standard Oil Co.'s engine laboratory. His conclusion is based on the greater flexibility of the spark ignition engine under varying load and speed, the high cost of fuel injection systems for Diesel engines and the rather rigid requirements for fuel for such engines of small power and high output. The field for small Diesels is for continuous use at nearly constant speed and reasonably steady load, such as trucks and tractors.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation.
WRITE POWER PLANT ENGINEERING.

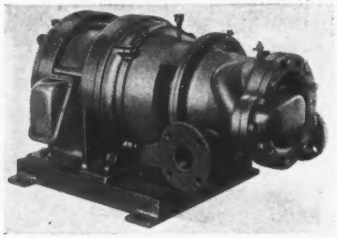
New Diesel-Powered Generating Plant

BARDCO CORP. OF AMERICA, Los Angeles, Cal., has introduced a new Diesel-powered generating plant unusually compact and designed to meet specific requirements of any desired voltage or frequency. A voltage regulator maintains a constant voltage irrespective of load

demands. Safety controls, which can be set at any predetermined point, give a warning signal in case of overheating or low oil supply and stop the engine before any damage can occur. A special oversized unit cleans the lubricating oil continuously as the engine operates to eliminate carbon, excess dilution and acid sludge. Sizes range from 10 to 100 kw., two to six cylinders.

Centrifugal Pump

ALLIS-CHALMERS MFG. Co., Centrifugal Pump Division, Milwaukee, Wis., has supplemented its line of single stage "SSUnit" type pumps by adding a 2½ by 1½ in. two stage "SSUnit" type pump good for heads up to 525 ft. at 3550 r.p.m. This pump has an efficient capa-

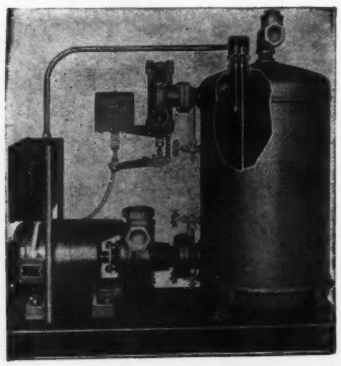


city range of from 50 to 100 g.p.m. against heads of from 300 to 500 ft. It is bolted to the motor frame by a splash-proof connection piece, the impellers being mounted on the special motor shaft extension, and the motor bearing also being the pump bearings as in the usual "SSUnit" construction. This pump is available with motors of from 10 to 30 hp. of the standard squirrel cage type, splash-proof or explosion proof types, and is adaptable for small boiler feed pumps—humidifier pumps in textile mills—air conditioning service—house pumps—small mine pumps—oil gathering, loading and small pipe line pumps and other small capacity, high pressure services. The standard pump has cast-iron casing and cover, and is bronze fitted. The impellers are placed back to back providing axial balance with the suction impeller next to the motor and the discharge passage from the first stage impeller cast integral with the main casing body and communicating with a passage in the cover leading to the inlet of the second stage impeller. This design permits the cover to be taken off, and the inside parts of the pump to be taken out without disconnecting the suction and discharge piping.

Self-Contained Boiler Feed Pump Unit

A NEW TYPE of boiler feed pump has been announced by The Johnson Corp., Three Rivers, Michigan, known as the Johnson Pressure Equalizing Boiler Feed Pump.

As the name implies, the basic principle employed in the new product consists of first equalizing the pressure in the receiving chamber of the pump unit before pumping its contents into the boiler. The operation is entirely auto-

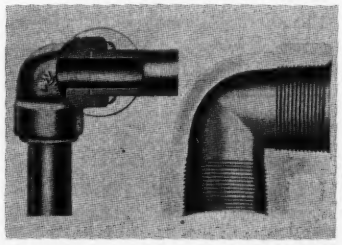


matic. As soon as the receiver is filled a valve is automatically opened admitting boiler pressure to the receiving chamber, thus equalizing it with the boiler pressure. Simultaneously the pump is started and operates until the contents of the receiving chamber are pumped into the boiler. The equalizing valve is then automatically closed and the pressure vented from the receiver so that condensate may again flow into it.

The operating cycle of the pump is controlled electrically by completing contact between the two electrodes which extend down into the receiving chamber as shown by the cutaway illustration. The whole unit is furnished complete and ready for installation as illustrated, for all boilers up to 150 hp. with working pressures up to 125 lbs.

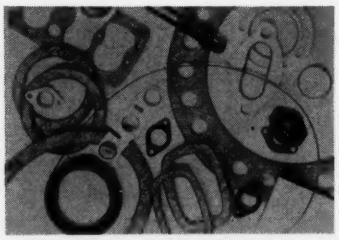
Forged Steel Fittings

THESE high-pressure fittings are drop forged from solid steel billets and bored from solid forgings. Threaded fittings have the bore of area equal to that of the pipe bore, with sharp threads, uniform thickness of wall and heavy bands at the ends. Socket-end welding fittings are simple of application and erection, the construction giving positive alinement and uniform bore area through pipe and fittings. They are made by The Watson Stillman Co., Roselle, N. J.



Bindedge for Gaskets

IT is now possible to make metal reinforced gaskets on the job, from any soft gasket material. The reinforcing is done with a channel-shaped, flexible strip of copper or other metal. This strip has serrated edges and preformed teeth and is fitted around gasket openings after the gasket has been cut. No special tools or skill are required. The teeth can be started, in most materials, with the fingers alone. The strip is cut



from a coil as required, and ends may be either butted together or slightly overlapped. The material is very flexible, readily formed around sharp corners and irregular outlines.

When pressure is put on the gasket, the teeth are firmly imbedded and the material is completely metal bound at points where strength is needed the

most. Any of the commonly used materials can thus be protected against pressure, corrosion, heat or other factors that frequently cause rapid deterioration.

This strip, called "Bindedge," manufactured by the Azor Corp., Newark, N. J., comes in 25 ft. coils and three sizes, for binding material from 1/32 to 1/4 in. thick. Bindedge not only makes metal reinforced gaskets, but is useful also for binding mounted maps, blue prints and drawings, and for protecting edges of many articles made from asbestos millboard, compressed or woven asbestos, fiber, felt, cardboard, paper, cork, rubber, fabric, or lead.

Indicating Wrench

BONNEY FORGE & TOOL WORKS, Allentown, Pa., has just introduced a new wrench known as the No. 66 Bonney Torque-Indicating Wrench. Features claimed for it by the manufacturer are that it includes ratchet mechanism that is reversible, lack of dials or gages to get out of order or that may be damaged by careless handling. The handle does not swing free when the desired torque is reached because the ratchet mechanism locks, thus preventing smashed fingers for the user.

The manufacturer claims that the accuracy of the wrench is greater than the consistent performance of the bolts on which the wrench is used. Its small head permits use in normally inaccessible places. It is not necessary to watch a dial or indicator to see when the desired torque has been reached, and there is no chance or error in reading a dial or gage.

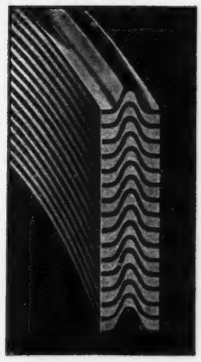
Simplicity of operation is one of the features of the wrench. The indicator is set at the desired torque in foot pounds. This is done by simply loosening an indicator clamping screw, moving the indicator to the desired position on the scale and then tightening the crew firmly. The ratchet lever is moved to the extreme left of the wrench.

The wrench is operated just as any ratchet wrench until the ratchet lever snaps to the neutral position in center. A sharp "click" is heard and the ratchet locks as a further indication that the desired torque has been reached.

To tighten the next bolt or nut it is not necessary to reset the wrench. The ratchet lever is simply moved back to position at the left of the wrench and the operation is repeated as on the previous nut or bolt tightened. Only when a change in torque is desired is it necessary to move the indicator.

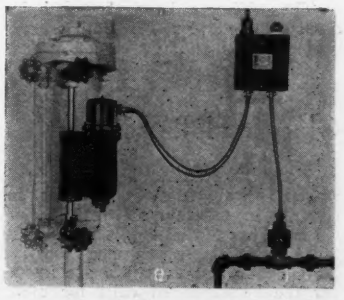
Spiral-Wound Gasket

SPIRALLY wound metal-asbestos gaskets of improved construction are being manufactured by the Azor Corp., Newark, N. J. It is claimed this Azor Flexiwound Gasket combines, to unusual degree, great mechanical strength, high resistance to corrosion and extreme temperatures, proper compressibility with relatively light bolting and resilience that is unequaled. The fact that maximum resiliency is retained for long periods of use, plus the ruggedness of spiral-wound construction, gives these gaskets remarkably long life. In many, or perhaps most services, it may be used a number of times with perfect safety and substantial savings in gasket costs. General purpose gaskets, recommended for use in all standard or special flanges, for boiler tube caps, handholes and manholes.



Automatic Boiler Water Control

THE JOHNSON CORP., Three Rivers, Mich., has just announced a number of important improvements in their Boiler Water Control equipment. Outstanding among these improvements is the redesigned electrode holder. This holder is installed either in the gage glass tappings by means of "Y" fittings as illustrated below, or with equalizing pipe, as conditions suggest. Its purpose is to complete an electric circuit when the boiler water level falls below normal level, the water itself acting as a conductor between the two electrodes and the ground to operate an electric feed valve or control a boiler feed pump.



In the re-designed holder the electrodes have the same type of insulation and construction that is used in heavy duty internal combustion engines. As a result they will withstand extreme conditions of pressure and temperature.

Other improvements have been made in the relay which controls the make-up valve of pump. The introduction of a third electrode provides for a low water cut-out circuit. A wider range of models is now built than formerly. Types include make-up water controls, electric pump controls, and steam pump controls with or without a low water cut-out as desired.

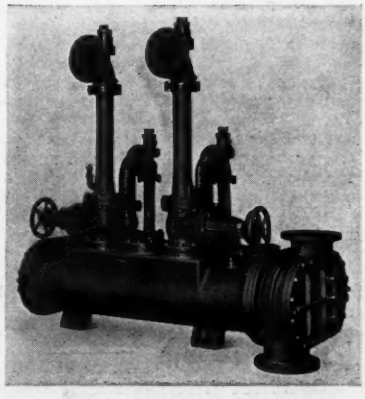
Universal Rotameter

SCHUTTE & KOERTING Co., Philadelphia, Pa., announces their new Universal Rotameter having three important advantages: The tapered tube can be inserted and taken out of the frame without disconnecting the pipe line, thereby avoiding leaky joints and misalinement. The pipe connections and frame of the Universal Rotameter are in one rigid piece thus eliminating any strains on the measuring tube. The SK Universal Rotameter allows 16 different connections.

Steam-Jet Ejectors

WORTHINGTON PUMP AND MACHINERY CORP., Harrison, N. J., recently announced its improved line of two-stage, condensing type, single and double element steam-jet ejectors.

These new units are equipped with removable Monel steam strainers integral with the nozzle heads, to eliminate clogging of the nozzles and facilitate minor adjustments. Parts subject to high pressure have been fabricated of improved materials, and safety valves are provided on the first stages of twin units to provide protection against closing of the interstage isolating valves at the wrong time. Overall dimensions have been reduced and designs for all sizes standardized.



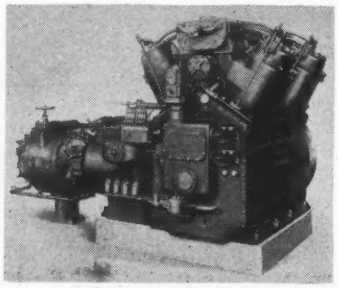
These two-stage ejectors have surface type inter and after condensers, and are generally used in connection with surface condensers serving turbines in steam power plants. They can also be used in industrial processes where valuable volatile constituents entrained in the gases being compressed can be recovered by condensing them in the inter and after condensers. These two-stage ejectors can also be provided with barometric jet type inter and after condensers for use in connection with industrial processes.

The single element ejector is used primarily on small units where temporary shut-downs are permissible and where reserve ejector capacity is not essential.

Each element of the twin unit is capable of handling normal capacity, and the unit is provided with suitable isolating valves to permit operation of either one or both elements. The spare element can be used for standby service or to take care of abnormal air leakage to the extent of doubling capacity.

Gas Engine Driven Compressor

THE COOPER BESSEMER CORP., Mt. Vernon, O., announces the introduction of its Type G-MV Compressor, a two-cycle, gas-engine-driven unit combining V-type power cylinders set vertically, and compressor cylinders arranged horizontally. This addition to the company's line of engines and compressors is rated 100 hp. per cylinder at a conservative speed of 300 r.p.m. Extreme compactness serves to make the G-MV



Compressor readily transportable, reduces the amount of floor space and materials necessary for its housing, lowers foundation material expense, and makes for welcome ease of installation. Shipped completely assembled, except for attaching the compressor cylinders, its factory alinements need not be disturbed and the unit is quickly and easily made ready for operation.

Designed primarily for compressor operations which include compressing air and gas, pumping wells by air and gas lift, delivering oil and gas to main lines and transporting them through long pipe lines, repressuring oil sands, and similar operations, these G-MV units also have numerous industrial applications such as furnishing power, compressing air and refrigeration gases and driving generators and pumps. These new compressors are offered in sizes of four, six and eight cylinders with a range of 400, 600 and 800 hp. respectively.

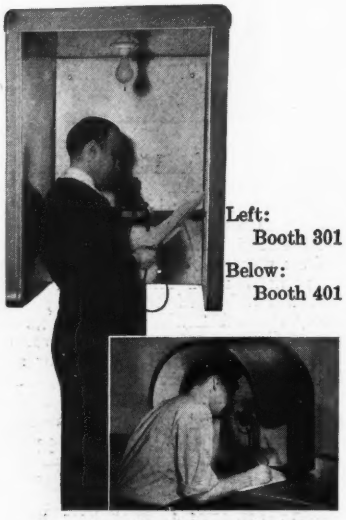
Insulating Cement

COPRTEX High Temperature Block and and Coprtex Heat Insulating Cement for service in high temperature equipment are two new products announced by Armstrong Cork Products Company of Lancaster, Pa.

Features of Coprtex Block are a high temperature limit of 1800 deg. F.; low lineal shrinkage; superior insulating efficiency; high modulus of rupture; accommodation of rivet heads and similar projections; lightness in weight; and availability in special as well as standard shapes. The manufacturer recommends Coprtex Cement for its high temperature limit; low lineal shrinkage; superior insulating efficiency; salvage properties; exceptional adhesiveness; and ease of application.

Phone Booths for Factories

DEVELOPED on the same principle as full length, floor type Burgess booths, these new acoustic phone booths are suitable for moderately noisy locations and for installations where space is limited. They are manufactured by the Acoustic Division of Burgess Battery Co., Chicago, Ill.



Left:
Booth 301

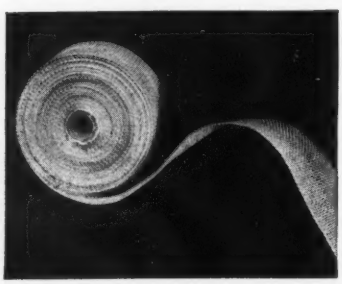
Below:
Booth 401

Model 301 is bolted to a wall or pillar, while Model 401 rests on a bench or desk. Instead of attempting to shut out extraneous noise, the Burgess Acousti-Booth absorbs it and prevents interference with the telephone user. This is accomplished by a special lining of perforated metal backed by a soft sound absorbent. This noise quieting principle was developed by C. F. Burgess Laboratories, Inc., and has been applied with success to difficult quieting problems such as engine mufflers, air ducts, airplane cabins, and truck cabs.

The wall-type booth has a built-in electric light and shelf. Both units are made of steel and require no servicing.

Glass Insulating Tapes

NEW ELECTRICAL insulating tapes, woven entirely from glass yarns, have recently been developed by the Corning Glass Works, Corning, N. Y. These tapes, with the appearance and flexibility of ordinary textiles, are intended for the insulation of coils for motors, generators, transformers, and for cables

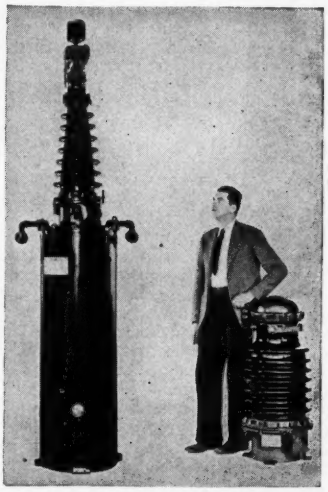


and other electrical conductors. As they are composed solely of glass, they not only have exceptional electrical properties and chemical resistance, but have the ability to withstand temperatures far in excess of the limits specified for class B High Temperature Insulation. They impregnate readily with resins, gums, and varnishes to form an insulation impervious to moisture and of high dielectric strength.

The flexibility and textile properties of these tapes are obtained from the extreme fineness of the glass fibres, which is from 1/15 to 1/20 the diameter of a human hair.

Size of Current Transformers Cut 50 Per Cent

A NEW OUTDOOR current transformer, equally as accurate and dependable as the older-style transformer it will replace, yet only one-half the size and weight, has been announced by the General Electric Co. These new transformers constitute a complete line in the 23- to 161-kv. range, and are available with either oil or Pyranol, a non-explosive, non-inflammable dielectric.



This progress in transformer design means reduced handling expense, reduced maintenance cost, greater convenience and economy in installation, and conservation of mounting space, since the height has been reduced to hardly more than one-third and the weight cut fifty per cent.

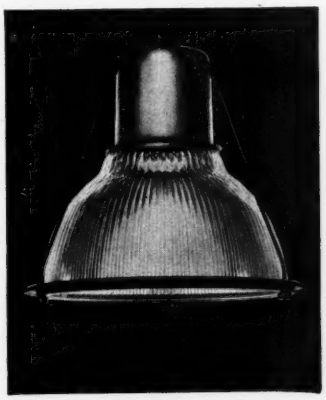
Despite the size reduction, accuracy is maintained to a high degree. Tests show that there is small variation in ratio correction factor, even when the primary current is but 5 per cent of rated value. Likewise, ratio characteristics on over-currents are accurately retained.

Pressure Indicator

ON PAGE 414 of the June 1938 issue is a description of a new pressure indicator made by the Bacharach Industrial Instrument Co. for measuring peak pressures in internal combustion engines. The correct address of the Bacharach Industrial Instrument Co. is Pittsburgh, Pa.

Wide Spread Lobay Reflector

HOLOPHANE Co., 342 Madison Ave., New York, N. Y., announces a new industrial reflector No. 682 for 300 and 500 watt lamp. The 90 deg. spread of light is ideal for lighting many industrial operations. This completes the very popular



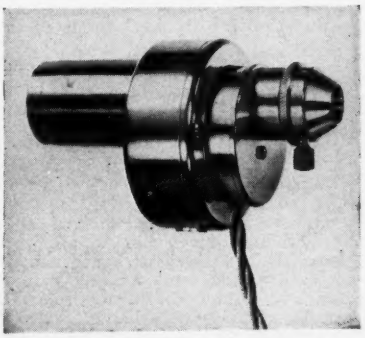
line of Holophane "Lobay" reflectors in the 300-500 watt size, and now offers the choice of a concentrating, intensive or widespread light distribution from units similar in appearance. The prismatic reflectors, which determine the light distribution, are interchangeable in the same fixture part. The features of these industrial units are safety, permanence and efficiency.

Ardometer Radiation Pyrometer

A NEW Radiation Pyrometer which uses as a temperature-sensitive unit, the Ardometer, is being offered by The Bristol Co., Waterbury, Conn.

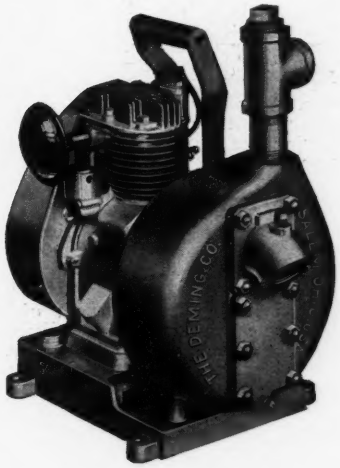
This instrument measures the surface temperature of hot objects or masses above 1000 deg. F., when the Ardometer unit is sighted so that it picks up the heat rays emitted. The temperature is recorded on one of Bristol's potentiometers — on a round or strip-chart recorder—or is indicated on a millivoltmeter pyrometer.

The Ardometer has this important feature: it can be sighted directly on the object in the furnace and in this position it measures instantly the temperature of the object itself. It follows with fidelity the temperature changes in the material on which it is sighted.



Self-Priming Centrifugal Pumps

DESIGNED for handling 600 to 20,000 gal. of water per hr., The Deming Co., Salem, O., has perfected a new line of completely automatic "Self-Priming" centrifugal pumps. One noteworthy feature of the new pumps is rapid and positive priming which is accomplished without the use of tanks, built-in strainers, hand operated controls or other mechanisms. There is nothing to clog or interfere with the free flow of water. Every priming operation is completely automatic and dependable with positive automatic shut-off for recirculating the water.



Built into the suction, the check valve holds the prime in the pump and suction line, ready to pump as soon as the pump starts operating. The impeller is the semi-enclosed, non-clogging type, designed to pass the usual solids encountered in dewatering work. A shaft seal prevents air from entering the pump case during the priming operation and during pumping. The new Deming "Self-Priming" centrifugal pumps are available in electric motor and belt driven units as well as gasoline engine drives. Both stationary and portable units are included in the line.

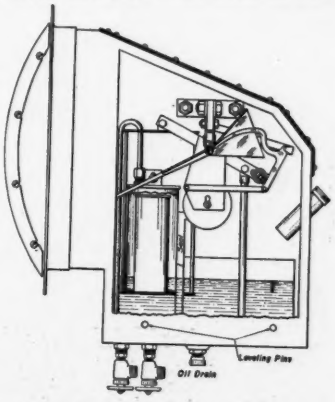
Megohmer

HERMAN H. STICHT & Co., 27 Park Place, New York City, have placed on the market a new model "DM" Megohmer which differs from the older instruments of this model in that the instrument has been re-designed so that it may also be used as a portable a.c. and d.c. voltmeter with a range of 600 v.

Many hundreds of these instruments have been sold in the past with a range of 0-100 megohms and with a 500 v. generator for insulation resistance measurements, with an extra binding post to permit of using the instrument as a portable d.c. voltmeter with range of 0.260 v. or 0-600 v. The re-design of the instrument was undertaken in view of the demand from various sources for an auxiliary scale to permit of using the instrument for both a.c. and d.c. voltage measurements.

Air Flow Gage

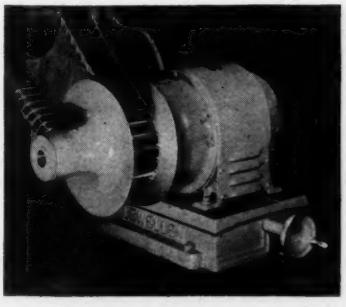
TO GIVE accurate flow indications of air or gases past an orifice, the Ellison Draft Gage Co., 214 West Kinzie St., Chicago, Ill., has introduced a new air flow gage. This gage may be calibrated in either c.f.m. or c.f.h. on a scale of equal divisions. This is made possible by a special square root movement which



consists of a pointer with a camtrack in the counter weight of the pointer and a cam linked to the gravity arm of the power unit. The power unit consists of a gasometer bell, moving within a stationary bell. The bell is provided with a seal which prevents oil from being blown out of the pan under pressure surges in excess of the scale range. This gage with two elements may be used as a fuel-air-ratio indicator for correctly proportioning the air and gas flow.

Variable Speed Motor Pulley

THE LEWELLEN MFG. Co., Columbus, Ind., has added to its line the new Lewellen variable speed motor pulley. This pulley fits the shaft of a standard motor and drives directly to a pulley or sheave on the driven shaft. The motor and pulley mount upon an adjustable base, which permits infinite variation of speed of the driven shaft. This pulley, which is modern in appearance and design, possesses several distinct features: Positive equalized disk travel in both



directions, maintaining belt in same position at all diameters; a uniform low spring pressure at all pulley diameters without buckling the belt; hardened steel driving members with ample bearing areas; pressure lubrication to all bearing surfaces, with all working parts, including the spring, completely enclosed, keeping grease in and dirt out.

Combination Belt Vulcanizer

FURNISHED for either 110 or 220 volts, a new light-weight, low-cost vulcanizer for vulcanizing belts up to 60-in. in width has been introduced by The B. F. Goodrich Co., Akron, Ohio. It is known as the 48-60 Combination Vulcanizer; weighs only 1650 lb.; has a total power consumption of 5000 watts.

This new vulcanizer is similar in appearance to the Goodrich double platen, water-cooled type except that it has only three hinged bolts at each side instead of six. It is not made on the bias, but is rectangular in shape. The platens are 65 in. wide and 12 in. long. This makes it possible to place the vulcanizer at a 10 deg. angle on a 60-in. belt, at a 22 deg. angle on a 54-in. belt, and a 30 deg. angle on a 48-in. belt.

Two advantages are gained by placing the vulcanizer at less than a right angle to the edges of the belt. First, any slight inequalities on the surface along the margin of the vulcanized portion will pass over the pulleys at an angle instead of straight across, and this gives much longer life to the splice. Second, placing the vulcanizer as nearly as possible parallel with the splice angle reduces the number of heats necessary to complete the splice.

Three New G. E. Welding Electrodes

THREE NEW ARC welding electrodes, each protected by a heavy extruded coating, have been announced by General Electric's Industrial Department. These electrodes, designated as Type W-20E, Type W-22E, and Type W-23E respectively, are intended for shielded arc welding of mild steel.

Type W-20E is especially designed for general-purpose, single- or multiple-pass arc welding of mild steel in any position to produce shielded-arc quality in excess of that required to meet paragraph U-69 of the A.S.M.E. Boiler Code. It is particularly suitable for high-speed, single-pass welding and for jobs where fit-up is likely to be poor. Spatter loss is low; the weld bead is smooth, and slag is easily removed. The flux coating is hard and not readily chipped, or damaged by moisture. Ductility of the deposit is unusually good and resistance to corrosion is comparable to that of mild steel. This electrode is recommended for operation with alternating current or direct current (straight polarity).

The Type W-22E electrode is designed for high-quality, single- or multiple-pass arc welding of steel in any position to produce shielded-arc quality in excess of that required to meet Paragraphs U-68 and U-69 of the A.S.M.E. Boiler Code. Ductility of the deposit is usually good, and resistance to corrosion is better than that of mild steel. This is a fast-melting, smooth-flowing electrode and with it dense deposits can be made without slag inclusions or gas pockets. Spatter loss is low; slag is easy to remove, and the weld bead is smooth. The coating is hard and not readily chipped or damaged by moisture.

Although vertical and overhead welding with this electrode is usually done with the 5/32-inch size or smaller, the 3/16-inch size can be furnished with two types of coatings, one for overhead and vertical work and the other for horizontal welding. This electrode is recommended for use with direct current (reverse polarity).

Type W-23E electrode is designed primarily for high-quality arc welding of mild steel in the flat position to produce shielded-arc quality in excess of that required to meet Paragraphs U-68 and U-69 of the A.S.M.E. Boiler Code. Ductility is excellent and resistance to corrosion is better than that of mild steel.

This is a high-current, or "hot" rod, so that the weld metal is quite fluid and washes up well on the side walls of deep-groove joints and fillets. Single- or multiple-pass beads can be made at high speeds without slag inclusions or gas pockets. Spatter loss is low and slag is easy to remove. This electrode also has a hard flux coating which is not readily chipped or damaged by moisture. A modification of this electrode is also available in coils with heavy taped coating for automatic welding. This type of electrode is recommended for operation with alternating current or direct current (reverse polarity).

Test Paper

FOR RAPID DETERMINATION of approximate pH values, the Micro Essential Laboratory has developed Hydroin, a wide range test paper which is being distributed by R. P. Cargille, 118 Liberty St., New York city. This paper gives 5 distinct colors in a range of from pH 2 to pH 10 and can be used with turbid and highly colored solutions by observing the color at the outer diffusion zone on spot tests. It is sold in vials of 100 strips for 30 cents each or cartons of 4 vials for $1.00.

Fluorescence Applied to New Light Sources

THE WESTINGHOUSE LAMP DIVISION, Westinghouse Elec. & Mfg. Co., announces the production of an illuminant employing an entirely new principle, fluorescence.

The new lamps, tubular in shape, are termed "Fluorescent Lumiline". They produce light by a novel method, differing from both incandescent and luminous vapor lamps, and giving much more light per watt, color for color. In tinted lamps from 30 to 50 times as much light per watt is produced by the new lamps as has been possible heretofore.

The Fluorescent Lumiline lamp utilizes a very low pressure mercury vapor discharge which produces ultraviolet radiation, giving very little visible light or heat radiation. The inside surface of the glass tube of the lamp is coated with chemicals which fluoresce, or glow when struck by invisible ultraviolet rays. These chemicals are "transformers" of radiation, changing ultraviolet to visible light. The efficiency of this process is extremely high and the transformation produces practically no heat. This fluorescent, glowing coating is the source of light in the new lamps.

The high efficiency of operation of the colored lamps is perhaps the outstanding characteristic of the Fluorescent Lumiline type. Also characterized by coolness in operation, the new illuminant runs only a few degrees hotter than the surrounding air. The negligible heat emission of the new lamp makes it well adapted for use in places where heat is objectionable. Its surface is low in brightness, reducing the chances of glare. Its tubular shape lends itself to architectural use. Both the shape of the lamp and its availability in colors should make it useful in decorative lighting.

Auxiliaries for current and switching control are required with fluorescent lumiline lamps.

Coal Pulverizer

KNOWN as the B&W Type E. Pulverizer, a new coal pulverizer characterized by low power consumption, high capacity for a given grinding-ring diameter, low maintenance, and quiet operation has been developed by The Babcock & Wilcox Co., 85 Liberty St., New York, N. Y.

High capacity for a given size and power consumption as low as 9 kw-hr. per ton of Pittsburgh seam coal pulverized to pass 65 per cent through 200 mesh result from outward radial flow of coal and improved classification of fines. Smooth, quiet operation result from isolation of the grinding elements from the housing, short main shaft and heavy construction, and its moderate speed.

The coal is pulverized by a single row of large-size balls between a stationary top ring and a rotating bottom ring driven from the base of the mill. Raw coal is fed to the inside of the upper grinding ring and, aided by centrifugal force, passes outward between the grinding balls. Preheated air passing upward between the grinding elements and the housing picks up the ground coal-particles, drying them as it carries them to a rotating classifier in the top of the pulverizer whence oversize particles are returned to the grinding zone for further reduction. Fineness of the coal delivered is regulated by the air flow through the mill. Capacities of the sizes now designed are from 2.0 to 13 tons per hour.

BUILDING CURTAIN WALL for steel frame buildings, Encased Insulating Board, consisting of 1 in. of insulating board with a ⅛-in. veneer of asbestos Flexboard, over which is applied a wall of Corrugated Transite is announced by Johns-Manville of New York City. For special positions, as between windows, the wall is of Encased Insulating Board having a ⅜-in. sheet of Flat Transite cemented to it. Insulation is stated to show by tests the equivalent of 14 in. of common brick and walls are stated to be fireproof and to withstand high temperature without cracking or buckling. Sheets of the board are held to the steel framework by cadmium-plated bolts, and joints are calked with a gray compound matching the light gray of the board, a system that is patented. No painting is needed but with a priming coat of boiled linseed oil, the walls may be painted any desired color. Other advantages stated are rapid erection, light weight, hence allowing lighter weight steel framing than for brick walls, and possibility of relocating walls with almost complete reuse of material.

News from the Field

CONNECTICUTT BLOWER CO., Hartford, Conn., through Charles H. Keeney, General Manager announces the appointment of Edw. F. Klick, Rochester, N. Y., as special sales engineer for the sale of its products in New York State. Mr. Klick has had a very broad, technical and practical experience in the blower line.

AMERICAN ENGINEERING CO. announces the appointment of Robert T. Forbes, 201 Devonshire St., Boston, Mass., as its representative in the New England territory for the A-E-CO Taylor Stoker Unit..

BERFORD BRITTAIN, 62, for 23 years Chicago Representative of Pittsburgh Piping & Equipment Co., Pittsburgh, Pa., died suddenly on Sunday, May 22, at his residence in Hinsdale, Ill. Mr. Brittian joined Pittsburgh Piping in 1915.

THE UNITED STATES SUPREME COURT, on May 16, held invalid certain recent patents held by the General Electric Co. on making of incandescent light bulbs and dismissed the company's infringement suit against the Wabash Appliance Corp., Brooklyn, N. Y. Over five billion lamps involved in this patent case have been sold.

General Electric contended that its patents secured in recent years were valid because they were legitimate improvements on the art of making light bulbs.

The Wabash firm asserted that General Electric "for a long time monopolized the lamp industry by means of patents" now expired, and that it "has endeavored to recapture its expired monopoly through trivial patents."

SHEFFLER-GROSS CO. announces appointment of Specialty Products Co., Boston, Mass., as exclusive distributors in the New England States for Duoflo Suction and Discharge Strainers.

THE MCALEAR MFG. CO. of Chicago announces the appointment of two new representatives in the south, with headquarters in Charlotte, N. C. Earl G. Embree will handle vapor and vacuum heating specialties and Charles M. Setzer and Co. will handle all of the McAlear Industrial and Power Plant equipment.

BIGELOW-LIPTAK CORP., Detroit, Mich., announces appointment of D. H. Skeen & Co., 1 No. LaSalle St., Chicago, Ill., as its district representatives in the Chicago territory. Kenneth Williams, president of the company is district manager.

THE MURPHY DIESEL CO., LTD., has appointed W. C. Morgan as district sales manager in the Southwest territory. Mr. Morgan will be located at Tulsa, Okla. William Mehler has been appointed Western District Manager and will be located at 255 Tenth St., San Francisco, Cal.

HARVEY B. MANN, long identified with De Laval and Cochrane sales in the Pittsburgh district, announces that he has established an office under the name Mann Engineering Co., 429 Penn Avenue, Pittsburgh, Pa., to represent the following manufacturers of engineering equipment: Fischer & Porter Co., rotameters; Fuller Co., rotary compressors and vacuum pumps; Richardson Scale Co., automatic coal scales; Springfield Boiler Co., water tube boilers; Sterling Engine Co., gasoline, gas and Diesel engines; and Bin Dicator Co., bin level indicator switches.

CULMINATING a reorganization plan instituted more than 2 yrs. ago, George A. McKenna, president and general manager of the Pomona Pump Co., Pomona, Cal., since 1925, recently announced a number of changes in executive personnel. D. C. McKenna becomes vice-president and secretary-treasurer; Jule H. Coffey vice-president in charge of sales; Claude C. Cook, formerly in charge of the St. Louis plant, vice-president in charge of manufacturing; Charles L. Barrett, general sales manager; R. D. Schott, chief engineer; Barclay Mackinnon, comptroller; while I. A. Oliver continues as consulting engineer.

DR. JOHN C. PARKER, Vice-President, Consolidated Edison Co. of New York, Inc., was elected President of the American Institute of Electrical Engineers for the year beginning August 1, 1938, as announced at the annual meeting of the Institute held in Washington, D. C., during the annual summer convention of the Institute. The other officers elected were: Vice-Presidents Chester L. Dawes, Cambridge, Mass.; F. Malcolm Farmer, New York, N. Y.; A. H. Lovell, Ann Arbor, Mich.; F. C. Bolton, College Station, Tex.; Lester R. Gamble, Spokane, Wash. Directors Leland R. Mapes, Chicago, Ill.; Harold S. Osborne, New York, N. Y.; D. C. Prince, Philadelphia, Pa. National Treasurer W. I. Slichter, New York, N. Y. (reelected).

L. B. HAMPTON has been made manager of the Pacific Northwest district of Crane Co., Chicago, succeeding F. A. Nitchy, who is retiring after 46 yr. service with the company. The district embraces the states of Washington, Idaho, nearly all of Oregon and Utah and parts of Nevada, Montana and Wyoming.

JAMES A. CRANSTON, whose work for the past 49 years in electrifying the Great West has established him as one of the pioneer salesmen of the electrical industry, voluntarily retired on June 1st from active service as Commercial Vice-President of the General Electric Co. at San Francisco. He first began selling electricity and electrical equipment in the Spring of 1889 for the old Northwest Thomson - Houston Company at St. Paul, Minn. Shortly after the Thomson-Houston Co. became a part of the General Electric Company in 1892, Mr. Cranston became manager of the Northwest territory with headquarters in Portland, Ore. and in 1923 Mr. Cranston went from Portland to San Francisco to become Pacific Coast Manager. In the same year he was elected a commercial Vice-President of the General Electric Company. He was born in Canada near Niagara Falls 76 yr. ago. His home is in San Francisco.

WALTER OWEN SMITH, 74, head of the claims department of Louisville Gas & Electric Company, died at his home in Louisville, Sunday, June 5. "Captain" Smith, as he was known to his many friends and fellow workers was the dean of the electrical industry in Kentucky, having entered the employ of the Louisville company 61 years ago, starting work in May, 1877. Mr. Smith helped to place the first electric light in Louisville and his adult life spanned the whole history of the development of the electrical industry.

A. E. ASHCRAFT, Fairbanks, Morse & Co. vice-president in charge of manufacturing, has announced the appointment of A. C. Howard to the position of general manager of the company's Beloit, Wis., plant. This position formerly was held by Mr. Ashcraft in addition to his executive control of all Fairbanks-Morse factories in the United States and Canada.

NEW OFFICERS of Greene, Tweed & Co., were elected at recent directors' meeting. F. J. Demarest is the newly elected president, with H. G. Russell as treasurer and general manager. J. A. McKeon remains as vice-president and H. A. Erwood as secretary.

J. J. B. RUTHERFORD, formerly of the research laboratory, U. S. Steel Corp., Kearny, N. J., has joined the metallurgical staff of The Babcock & Wilcox Tube Co. as research metallurgist.

OFFICERS ELECTED for the 1938-'39 season of the Chicago Section of the American Society of Mechanical Engineers at the annual dinner meeting on June 10, are: chairman, Ralph E. Turner, editor, POWER PLANT ENGINEERING; secretary-treasurer, Fred B. Orr, Illinois Maintenance Co.; vice-chairman, L. M. Ellison, Ellison Draft Gage Co.; Frank C. Everett, Ortman, McClure, Hadden Co.; H. F. Hebley, Commercial Testing & Engineering Co., and B. D. Stevens, Miehle Printing Press & Mfg. Co. The meeting was addressed by Dr. John W. Finch, director, U. S. Bureau of Mines, on the subject of Mineral Vitamins.

THE POWER PIPING DIVISION of Blaw-Knox Company, Pittsburgh, Pa., has opened a southern sales office in the Candler Building, Atlanta, Ga. O'Earl Kearney, who has had extensive experience in the power plant and industrial piping fields during the past 20 yr., will be in charge.

OFFICERS ELECTED at the thirty-second annual convention of the Smoke Prevention Association, at Nashville, Tenn., are: William Culbert, president, chief smoke inspector, Nashville, Tenn.; Stanley C. Higgins, first vice-president, secretary of the New River Coal Operators' Association, Mt. Hope, W. Va.; H. V. Carlson, second vice-president, New York Central R. R., Chicago, Ill.; F. A. Chambers, secretary-treasurer, chief smoke inspector, Chicago, Ill., and Howard Keyes, sergeant-at-arms, C. M. & St. P. R. R., Oak Park, Ill. Milwaukee, Wis. was chosen as the convention city for June, 1939.

Way Back When

WAY BACK in 1892, when power plant engineers wore whiskers, Mr. Haynes was sitting in his office when in walked M. H. Detrick, of Detrick arch fame, with a camera and took this picture. Photography, you see, has not advanced so much as far as perfection of detail is concerned, but engineering has. At that time Mr. Haynes was chief engineer of the cable car power house at 21st and State streets in Chicago. Note the steam gage testing outfit; this was the sum total of the testing equipment in use in those days. Mr. Detrick, who at 76 is still hale and hearty, brought this picture in a few weeks ago and asked us whether we could use it. We could.

Dean Heald, 34, President of Armour Institute

ACCORDING to a recent announcement Dean H. T. Heald, who is only 34 yrs. old, was elected to the presidency of Armour Institute of Technology at a meeting of the Board of Trustees held at the Union League Club of Chicago.

President Heald fills the office vacated last October 12th by Doctor Willard E. Hotchkiss, noted economist who resigned to devote all of his time to civic interests. Mr. Heald received his undergraduate training at Washington State College, where, in 1923, he was awarded the degree of Bachelor of Science in Civil Engineering.

From the time Mr. Heald received his first degree in 1923, until he came to Armour Institute of Technology, in 1927, his training was not as an educator, but as an engineer in field work. He served as junior engineer for the United States Bureau of Reclamation at Pendleton, Oregon, from June of 1923 until September of 1924. His duties in this connection included the design and layout of construction equipment, living quarters, water system, etc., of the McKay Dam, as well as estimating and inspection.

A.S.T.M.

AT THE 41st Annual Meeting of the A.S.T.M. at Atlantic City last month, Robert H. Heyer, junior metallurgist, Research Laboratories, The American Rolling Mill Co., was awarded the Charles B. Dudley Medal for 1938. This medal commemorates the name of the first president of the A.S.T.M. and is awarded to the author or authors of the paper presented at the preceding annual meeting and which is of outstanding merit as an original contribution on research in engineering materials. The paper was entitled "Analysis of the Brinnell Hardness Test" and was based on a thesis presented at Purdue University in partial fulfillment of the requirements for Ph. D.

At the same meeting announcement was made of the election of the following officers: President, T. G. Delbridge, Manager, Research and Development Dept., The Atlantic Refining Co., Philadelphia, Pa.; Vice-president, W. M. Barr, Chief Chemical and Metallurgical Engineer, Union Pacific Railroad Co., Omaha, Nebr.

A. S. M. E. Nominees

AT THE BANQUET June 22, held in connection with the Semi-Annual Meeting, at St. Louis, Mo., of the American Society of Mechanical Engineers, the following nominations were made for officers to serve for the year 1939. Election will be made by letter ballot, the results of which will be made known in the latter part of this year.

For President: A. G. Christie, Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md. For Vice Presidents: W. L. Dudley, Westwind Corp., Seattle, Wash.; Jas. W. Parker, Detroit Edison Co., Detroit, Mich.; Alfred Iddles, Babcock & Wilcox Co., New York, N. Y. For Managers: W. R. Woolrich, Dean of Engineering, University of Texas, Austin, Texas; Clarke Freeman, Mutual Fire Ins. Co., Providence, R. I.; W. H. Winterrowd, Franklin Railway Supply Co., Chicago, Ill.; and, to fill a vacancy left by the death of B. M. Brigman, H. H. Snelling, Snelling & Hendricks, Washington, D. C.

Arthur P. Van Schaick

ARTHUR P. VAN SCHAICK, vice-president of the American Chain & Cable Co., Inc., died at midnight, June 7, while traveling from New Orleans to Chicago on the Panama Limited. Following a month's vacation at Beaumont, Cal., Mr. Van Schaick was en route with Mrs. Van Schaick, to their home at Southport, Conn.

As Vice President in Charge of Sales for the American Chain & Cable Co., Mr. Van Schaick's duties carried him to all parts of the country, and he possessed a wide acquaintance in manufacturing, wholesaling and railroad circles. He was also a Director of American Chain & Cable Co., a Director of the Chain Institute, and former President of the American Hardware Manufacturers' Association.

Born in Chicago, December 29, 1882, he was the son of Mr. and Mrs. Anthony Gerard Van Schaick, and the grandson of the late Governor Harrison Ludington of Wisconsin.

Silver Anniversary

ON JUNE 2, the Silver Anniversary of the Northern Equipment Co., Erie, Pa., Ed. Nick and Vince Veenschoten were showered by congratulatory telegrams from all parts of the country. With unlimited faith in the then radical principal of continuous boiler feeding, Ed. Nick and his associates bought the company on June 2, 1913 and the growth of the organization over a period of 25 yr. is proof that this faith was well placed.

New York Power Show

NINE new members, recently nominated, have been appointed to the Advisory Committee of the Thirteenth Exposition of Power and Mechanical Engineering, which will be held at Grand Central Palace, New York, during the week of December 5 to 10. The new members of the committee are Comfort A. Adams, E. G. Budd Mfg. Co.; J. T. Barron, vice-president in charge of electric operation, Public Service Electric & Gas Co.; R. E. Dillon, vice-president in charge of production and engineering, Boston Edison Co.; Crosby Field, president, American Society of Refrigerating Engineers; A. C. Fieldner, chief mechanical engineer, U. S. Bureau of Mines; N. E. Funk, vice-president in charge of engineering, Philadelphia Electric Co.; George L. Knight, vice-president, Brooklyn Edison Co., Inc.: Joseph Pope, Stone & Webster Engineering Corp.; and Alfred Vaksdal, plant engineer, Corning Glass Works.

For the Engineer's Library

Any Catalogs that you wish will be gladly sent. Write Power Plant Engineering.

Controls Meters and Instruments

Micromax Recorders and Indicators—In a 20-page catalog under this title, the description of instruments is prefaced with a discussion of considerations responsible for the increasing use of equipment for frequency measurement and for frequency-load control. Illustrations show modern installations in steam, hydro and Diesel plants, large and small, as well as in load dispatchers' offices and in laboratories. A copy of Catalog N-57-161 will be sent on request to Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa.

Liquid Level Indicators—Just issued, and fully illustrated with photographs and blue-prints, Bulletin No. 382 describes construction and operation of remote reading liquid level indicators for boiler water level control. The Reliance Gauge Column Co., 5902 Carnegie Ave., Cleveland, Ohio.

Mechanical Power Transmission

Silverlink roller chain and sprockets for drives and conveyor uses are described in a new data book No. 1757 containing 174 pages of practical information, application pictures, and engineering data, including many new chains and features not hitherto published. This book covers Silverlink roller chains of manufacturers' (A.S.A) standard sizes, non-standard sizes and "heavy sizes." Included also are multiple-width roller drive chains, with ultimate strengths ranging up to 460,000 lb. Twist-Type, a particularly outstanding chain, a Link-Belt engineering development covered by U.S.A. and Canadian patents, and not hitherto announced is also included in the booklet. This chain is provided with axial clearance to accommodate a normal amount of twisting action. Notes, formulas and tabular data are given on how to select the proper combination of chain and wheels for an efficient drive. These instructions are much simpler than those previously published. Engineers will no doubt be particularly interested in the new graph shown under the heading "Desirable Chain Centers". Twenty-two pages are devoted to tabulation and uses of Silverlink roller chain on conveyor work. Included in the data book is the new Link-Belt line of stainless steel and bronze chains. Tables are presented to show the extent to which stainless steel chains will resist the many agents of corrosion listed. Much valuable information also is given with reference to the uses for bronze chain. This is Link-Belt's first publication of data on this subject. A copy of the new book will be sent to anyone having occasion to select, order, use or maintain equipment of this character. The request should be made on business letterhead, and may be addressed to Link-Belt Co., 519 North Holmes Ave., Indianapolis, Ind., or to the nearest office of the company.

Boilers and Accessories

Stokers—Catalog 300, a well illustrated book of 24 pages and cover presents an unusual treatment of the stoker story and is fully descriptive of all details of Kol-Master's many patented and exclusive features of design, construction and operation. It covers the entire line of Kol-Master domestic, commercial, institutional and industrial models ranging from 30 lb. to 1600 lb. per hr. A special eight-page booklet covering Kol-Master "S" models for Scotch Marine and other long, low, narrow firebox boilers and furnaces describes Kol-Master's unique ability to fire Scotch Marine and similar jobs. Copies of both the catalog and booklet will be sent upon request to Kol-Master Corporation, Oregon, Ill.

Steam Generator—Bulletin F9 illustrates and describes Keeler Type CP steam generator, listing 12 features. Also included is a table showing the principal dimensions of standard settings for use of the engineers and architects in preliminary layout work. E. Keeler Co., Williamsport, Pa.

Elesco Economizers—A new 16-page catalog deals with the latest designs and details of Elesco fin-tube economizers. These are of two general designs—Type A in which the ends of the bifurcated tubes are connected by bends with flanged connections, and Type C in which forged return bends are employed. The former type is for use where feedwater conditions make ready access for internal inspection or cleaning desirable and the latter is for use where internal cleaning is not required. Combustion Engineering Co., Inc., 200 Madison Ave., New York, N. Y.

Multiple Spreader Stoker—Bulletin 77 is devoted to a complete treatise on the Fyr-Feeder multiple spreader stoker showing what it is, how it operates and giving the cost of operation. American Coal Burner Co., 155 E. Superior St., Chicago, Ill.

Fly-Ash, Its Correction is the title of a new booklet giving a clear and forth-right presentation of the practical aspects of fly-ash collection. Buell Engineering Co., Inc., 70 Pine St., New York, N. Y.

Compressors and Lubrication

Reclaiming Oil—Three new bulletins, one describing the Luploil Process for reclaiming lubricating oil used in all industrial equipment. The dehydrator and degasifier for lubricating oil for turbine generators is the subject of the second. The subject of the third is hydrovolifier with earth treatment, a system for continuously rerefining insulating oils. The Buckeye Laboratories, Inc., Alliance, O.

Manzel Forced Feed Lubricators are completely illustrated and described in a new 12 page catalog 94-B which has just been issued by Manzel Brothers Co., Buffalo, N. Y.

Compressors—Type G-MV Two-Cycle Compressor and Type G-MS Two-Cycle Compressor units are described in two new bulletins recently issued by The Cooper-Bessemer Corp., Mt. Vernon, Ohio.

Refractories

Super-Duty Brick for Super-Duty Service—The context of this eight-page catalog points out the factors which led to the development of these refractories in which definite properties have been developed to meet service conditions beyond the limits of high heat duty fireclay brick. Alamo and Varnon brands have become widely established for service under extremely severe working conditions. The folder contains information concerning their manufacture, properties and applications. Harbison-Walker Refractories Co., Farmers Bank Bldg., Pittsburgh, Pa.

Refractory Products—In a new 20-page engineering data book, Johns-Manville has made available full information on the J-M line of refractory products which this company has developed to fulfill the diversified requirements of modern industrial practice. The descriptive material includes data on the character or base of each product, its highest working temperature, the number of pounds needed to set 1000 brick or form one cubic foot of construction, and the form in which the product is furnished. Also included is a comprehensive table which lists separately the various types of heater equipment used in these different industries. For each piece of equipment, the table describes the parts requiring a refractory cement and recommends a specific product for the job. Copies of the book, Form DS Series 700, are available upon request, to Johns-Manville, 20 East 40th St., New York, N. Y.

Miscellaneous

The Morse Filter Plant is the title of a new bulletin recently issued, describing the company's new type of plant in which various component parts are combined in one compact unit. The mixing chamber, coagulating basin, filters and clear water reservoir are arranged in a series of concentric cylinders, with the pipe vault in the center and the control room above. The bulletin is illustrated by drawings and by photographs of the Washington Suburban Sanitary District Plant at Burnt Mills, Md. The Chicago Bridge & Iron Co. of Chicago, Ill.

Cooling Towers—Two new bulletins illustrate and describe induced draft cooling towers giving specifications, sizes, dimensions and weights. Bulletins 500 and 502 may be had on request to The Marley Co., 3001 Fairfax Road, Kansas City, Kans.

Air Cooling Units—Ice and Frost Bulletin 185-A describes air cooling units for cold storages, meat chilling and processing room, dairy and ice

cream plant, locker systems, low temperature work and fur storage. Frick Co., Waynesboro, Pa.

Packing—A folder describing the new Garlock Bitan leather packings, which are so treated by an exclusive Garlock process that they operate successfully against extreme pressures and under severe service conditions, has recently been issued by The Garlock Packing Co., Palmyra, N. Y.

Buromin, a glass-like quickly soluble, pure chemical used for the purpose of boiler water conditioning, is completely defined in a new bulletin recently issued by The Buromin Co., 300 Ross St., Pittsburgh, Pa.

Koppers Yearbook 1938—The book gives the complete story of the Koppers Co., the industrial organization which in 24 yr. has quietly grown to become a producer of products for nearly every type of industry in the nation. The book tells what the products are and how they are obtained. It gives a complete description of the company's subsidiaries and how they operate and gives a complete account of the company's finances. Koppers Co., Pittsburgh, Pa.

Piping

Piping—Walworth Catalog No. 89, a new 602-page catalog covering the complete line of Walworth valves, fittings, pipe and tools, has just been published. Many added features are embodied in the catalog which should render it of increased usefulness to engineers, contractors, plumbers, plant superintendents, purchasing agents and others interested in the Walworth line of products. In the center, for instance is a red index permitting quick reference to each class of product listed in the book. Arrows on the red index pages point to the section markers at the beginning of each classified section. Copies of the catalog are available to those who request them on their company letterhead. Address the Walworth Co., 60 East 42nd Street, New York, N. Y.

Homestead Valves, a new 48-page book under this title features a more complete line of boiler blowoff valves; several new lines of lift-plug valves; more complete dimensions, tables, and facts about Homestead Valves; a new line of semi-steel 500 lb. O.W.G. (oil, water, gas) valve for the oil industry, and prices which are generally lower. In addition, there are three full pages of suggsteed uses for valves in all industries, and suggested metals for special service conditions which users find very helpful in solving valve problems. Homestead Valve Mfg. Co., Coraopolis, Pa.

ADSCO Vertical Steam Trap—A new, illustrated, 4-page, two color Bulletin No. 35-86, giving details of construction and installation hookups on the ADSCO Vertical Float Type Steam Trap with or without thermostatic air by-pass, is available by addressing the American District Steam Co., North Tonawanda, N. Y.

Electrical Equipment

Secondary Networks and Network Transformers—This 20-page illustrated booklet describes the application, construction and design of Westinghouse Network Transformers and other network equipment. Savings in installation and operating costs of underground networks include the following: underground equipment cuts land or rent charges, eliminates converting equipment, same secondaries can be used for power and light, and continuity of service is maintained without use of duplicate feeders or storage batteries. Overhead, spot, and vertical networks and their respective fields of application are also described. Copies may be secured from Westinghouse Elctric & Mfg. Co, East Pittsburgh, Pa.

Electrical Equipment—Six new bulletins under the following subjects have recently been issued by the Genral Elctric Co., Schenectady, N. Y.: GEA-2678A, G-E Photoelectric Relay; GEA-2234B, Manual Motor-Starting Switch; GEA-743B, A-C Reversing Drum Switches, CR3202; GEA-2907, Alnico Limit Switch, CR9440-B1B; GEA-2908, Oil-proof push button and selector switch; GEA-19H, A-c Magnetic motor-starting switch.

Convertible Slip Ring Motors—Bulletin M-2 gives a thorough analysis of the requirements demanded of the standard wound rotor type of slip ring motor, including specific information describing how P&H motors are designed and manufactured. It also describes the standard conversions for four types of service possible with P&H Convertible Slip Ring Motors. Copies may be obtained by writing the Harnischfeger Corp., 4400 W. National Ave., Milwaukee, Wis.

Voltage Regulator—Bulletin 1185A describes recent changes and developments in the BFR branch feeder voltage regulators. The operation and general design features of the unit are described in detail and the publication is said to be of considerable interest to operating and distribution engineers. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Prime Movers

Engines—A 36-page booklet, Bulletin S 500-B13, illustrating various installations of Diesel and gas engines, was recently published. Worthington Diesel engines are of the heavy duty type, ranging from 50 to 1500 hp. at speeds from 225 to 600 r.p.m. The modern vertical four-cycle single-acting direct-injection design is the result of experience in building all types of engines: horizontal and vertical; two-cycle and four-cycle; single-acting and double-acting; and air-injection and direct-injection, and is generally accepted as offering the highest attainable operating economy and reliability. Worthington gas engines range in size from 30 to 1800 hp. and are designed to operate on natural, manufactured, refinery, sewage-sludge, producer or any mixture of gases. The characteristics of Worthington's vertical gas engines follow closely those of its Diesel engines, while the horizontal double-acting gas engines operate at speeds from 125 to 200 r.p.m. Widely used on gas compressor service, the latter are also suitable for general power requirements where gas fuel is available. This bulletin contains nearly 100 illustrations of Worthington engines in service, demonstrating their wide range of sizes and services. Worthington Pump & Machinery Corp., Harrison, N. J.

Steam turbines—Small steam turbines for driving auxiliary machinery, such as generators, pumps, fans, etc., are described in Catalog C. These turbines are of the velocity stage type and, when operated at suitable speeds, as in connection with high speed machinery or by the use of speed reducing gears, and exhausting to back pressure, show good efficiency. The design has been specially adapted to the use of high pressure, high temperature steam by locating the steam chest in the upper part of the casing cover, where it is above and well removed from the bearings. De Laval Steam Turbine Co., Trenton, N. J.

New Plant for Marley Co.

THE MARLEY CO. recently moved into its big new building at 3001 Fairfax Road, in Kansas City, Kan. The main structure, 180 by 180 ft., houses the factory and warehouse on the first floor with national headquarters offices on the second. It is equipped with a modern heating and ventilating plant, including 32 tons of air conditioning for the offices. The Marley plot, in the Fairfax Industrial District, is 213 x 415 feet.

Beginning in 1922, as manufacturer's representative for several nationally known lines, the Marley Co., in 1926 perfected and offered to the public the Marley spray nozzle. It met with immediate acceptance and with this success, Marley pioneered the application of spray distribution to atmospheric deck type water cooling towers and other phases of cooling work.

The startling growth and consequent expanding requirements brought about a serious need for adequate quarters and improved shipping facilities. With the new building more room for factory operations, increased storage space and the means of speedier freight handling at the home plant are now provided.

New Engineering Books

Internal Combustion Engines — By Howard E. Degler. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Size 6 by 9 in., 3999 pp. cloth bound. Price $4.00.

As a comprehensive review of the theory, design, application and performance of internal combustion engines this book has been well done. It is written on the assumption that the reader has a working knowledge of thermodynamics and mechanics so that these parts have in general been limited to a brief review except where a more extensive treatment is desirable because it has a direct bearing on engine design. Much of the theory is concerned with fuels and combustion, a matter of increasing importance as higher engine speeds and smaller cylinder dimensions makes combustion chamber shape and fuel supply doubly significant.

A brief introduction on development and application is followed by three chapters dealing with theory as outlined above. This is followed by five chapters on the major types of engines, general design principles being illustrated by drawings and photographs of typical commercial engines. Four chapters then take up major portions of the engine, accessories and auxiliaries, and the balance of the book is taken up with engine tests, performance and economics. Engine test procedure has been well standardized and an abstract of the A.S.M.E. Test Code for internal combustion engines and S.A.E. Test forms have been included in the appendix for completeness.

Simplified Methods for Computing Stresses in Rigid Frame Buildings. By Sheldon A. Keast, published by Lefax, Inc., 9th & Sansom Sts., Philadelphia, Pa. Loose-leaf, 40 pages, paper cover. Price $1.00.

Simplified methods, simply explained and illustrated by examples, for computing stresses due to vertical and lateral loads in multi-storied buildings in which the girder to column connections are rigid or semi-rigid. It is intended primarily for the experienced designer and although the methods are greatly simplified, they have been found by the author, who is a structure engineer of the Bureau of Building Inspection, Philadelphia, sufficiently accurate for practical design purposes.

Statistical Methods—By George W. Snedecor. Published by the Collegiate Press, Inc., Ames, Iowa. Size 6 by 9 in., 333 pp. Price $3.75.

Of recent years the use of statistical analysis of data for the purpose of interpretation and simplification has been greatly extended. Although based upon mathematics and mathematical probability, statistical methods are widely used by those without a sufficient mathematical background to appreciate the reasons for the complex statistical methodology that has grown up.

From the mathematical side there is no lack of texts and literature on this subject. Even those with a considerable knowledge of mathematics may, however, have difficulty in taking a text which treats statistics as a branch of mathematics and apply the dice, card and other games of chance examples to the problem of interpreting their own experimental data.

The author believes that statistical methods can be used competently by those not especially trained in mathematics and the book is aimed at the novice, with mathematics limited to arithmetic. The presentation is entirely practical, one idea or concept being presented at a time and fully developed by examples. In fact the examples are an indispensable part of the presentation. They inform the novice, guide the advanced student and point out short cuts of calculation to the practicing statistician.

For the engineer the book has two disadvantages. First, the examples and specimen data are taken from agriculture and biology. Second, a good portion of the book is devoted to explaining without mathematics what could be simply demonstrated by a few equations. Herein lies the wide appeal of the book, however. The non mathematical reader gets a working knowledge of the methods and phraseology such as chi-square, deviations, regression, variance, binomial and Poisson distribution, without feeling that a large part of the text is over his head. The mathematical reader can get the same working knowledge and if interested in development of the methods can obtain them from the numerous references given with each chapter. The engineer intelligent enough to understand the methods can easily adapt the examples to data drawn from his own field.

All in all, the book is a remarkable contribution to statistical analysis, a working manual for those interested in statistics as a practical tool for the more effective use of data of all kinds.

Inventions and Their Management—By Alf. K. Berle and L. Sprague De Camp. Published by the International Textbook Co., Scranton, Pa. Size 5 by 8 in., 693 pp. flexible fabricoid binding. Price $4.50.

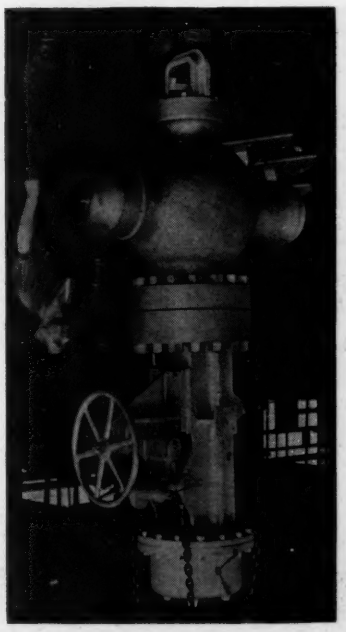
If the inventor is to reap the benefits of his invention, he must inform himself of the procedure that must be followed and the pitfalls that must be avoided in its promotion. This book is intended as a guide to inventors in every phase of their work and to help them over difficulties that other inventors have met. It teaches the language of invention used by attorneys, engineers and executives who work in this field. In short, the book aims to present a coordinated treatment of the problems confronting inventors and business men in developing ideas into industrial property of value. This has been done to a large extent by examples carefully selected to illustrate the point in question.

In carrying the matter beyond the patent stage to the actual promotion, marketing, evaluation and sale the book becomes of increasing value to the independent inventor who is often not able to reap the material benefits of his ingenuity. The value of the book for practical use is further enhanced by a bibliography, a list of patent association in the country, a list of libraries receiving current patent office publications and a 23-page glossary of words and phrases commonly used, many of which have a special meaning when used in connection with this subject.

One Up for Windsor

YOU PROBABLY THINK that our proof reader was asleep but he wasn't—we planned it that way although our printer still thinks we are crazy. An upside down cut is the one unpardonable crime of publishing and getting this one down proved to be more difficult than backing an auto from New York to Philadelphia. It shows a 10 in. Smoot-Republic oil operating reducing valve for the Ohio Power Co. section of Windsor Station. This type of valve is installed with the operating cylinder on the bottom so as to eliminate fire hazard from possible oil leakage over the hot valve body. After being tested, assembled and tested again, the crane operator found it more convenient to handle the valve upside down on its way to the shipping room.

Windsor Station was described in an article by Philip Sporn on page 307 of the May issue. This valve, designed to reduce 700,000 lb. per hr. from 1400 lb., 950 deg. to 225 lb., is one of two for the reducing and desuperheater bypass around the 60,000 kw. top turbine. The double ported body and single piece valve and stem are carbon-moly steel and the seats stainless steel. A regulator, bolted to the face plate A, controls the flow of oil to the top and bottom of the piston through openings B. Manual operation is provided by the hand wheel and bell crank which are normally free from the valve stem. To operate the valve by hand it is first necessary to engage arm C in a hole provided in part D and then to open an oil bypass around the piston. The overall dimension of the valve is almost 11 ft. and the valve travel $1\frac{7}{16}$ in.



Power Plant Construction News

Ala., Tarrant City—Birmingham Water Works, Birmingham, Ala., plans construction of large electric-operated pumping station and new filtration plant in connection with extensions and improvements in water system at Tarrant City and East Lake. New pipe lines will be installed. Entire project will cost close to $400,000. H. B. Richards is general manager.

Calif., Huntington Park—Desser Tire Products Co., 6211 Cottage Street, plans installation of electric power equipment in connection with rebuilding of portion of automobile tire-manufacturing plant, recently destroyed by fire, with loss reported over $400,000. Reconstruction will approximate a like amount.

Calif., Sacramento — Bercut-Richards Co., plans installation of electric power equipment in connection with rebuilding of portion of local food product canning and packing plant, recently destroyed by fire, with loss totaling close to $400,000. Proposed to begin work soon.

Conn., Shelton—Briesenick-Shelton Co., Derby, manufacturer of wire reels, etc., plans installation of electric power equipment in new one-story plant on Nichols Road, Shelton, where property has been acquired. It will replace company plant at Derby, recently destroyed by fire. Entire project will cost close to $60,000.

Ga., Savannah—National Gypsum Co., 190 Delaware Avenue, Buffalo, N. Y., plans power house at proposed new wall board and plaster mill in Port Wentworth district, Savannah, where tract of land is being selected. Entire project will cost close to $1,000,000. Proposed to begin work in near future.

Ind., Bargersville — Town Council plans early call for bids for equipment for municipal pumping station for waterworks system, including 100-gal. per min. deep-well turbine pumping unit and accessories, and 75,000-gal. capacity elevated steel tank and tower. John W. Moore & Son, Indiana Pythian Building, Indianapolis, Ind., are consulting engineers.

Iowa, Belmond—City Council has plans for new municipal electric light and power plant. Cost estimated at $120,000 with engine-generator unit and auxiliary equipment. A special election has been called to vote on project. Financing will be arranged through Federal aid.

Iowa, Dayton—City Council is planning new municipal electric light and power plant, estimated to cost about $55,000. A special election has been called to approve project. Proposed to arrange financing and proceed with project at early date.

Kan., Kansas City—Meyer Kornblum Packing Co., 300 Central Avenue, plans installation of electric power equipment in new two-story addition to meat-packing plant, 40 x 120 ft., for which bids will be asked soon on general contract. Entire project will cost over $50,000. Carl Schloemann, 6329 San Bonita Avenue, Clayton, Mo., is architect.

Ky., Louisville—John G. Epping Bottling Works, Inc., 712 Logan street, plans installation of power equipment in new two-story addition to mechanical bottling plant, 30 x 125 ft. Cost estimated over $75,000. Work is scheduled to begin soon. Carl J. Epping, 806 East Broadway, Louisville, is architect.

Ky., Vanceburg — Lake County Board of Commissioners, Vanceburg, has plans maturing for new county-owned electric light and power plant, estimated to cost about $148,000, with engine-generator units and accessories. Financing has been arranged. Proposed to begin work soon.

La., New Orleans—United States Engineer Office, First District, New Orleans, will receive bids until July 7 for four oil-fired, sectional header, watertube, cross-drum, marine-type boilers, complete with oil burners, soot blowers, fittings, tools and spare parts. Each boiler unit to have a heating service of not less than 3615 sq. ft. (Proposal 318).

Md., Gwynnbrook—Hunter Baltimore Rye Distillery, Inc., 1900 East Fort Avenue, Baltimore, has plans for new boiler plant, 49x50 ft., and pumping station, 30x33 ft., at plant at Gwynnbrook, near Baltimore. Work is scheduled to begin soon. Cost estimated over $50,000, with equipment. Moehle & Associates, 217 West Franklin street, Baltimore, are architects.

Mass., Weston — Massachusetts Broken Stone Co., Waltham, Mass., is considering rebuilding a portion of Diesel engine-electric plant at plant at Stonybrook, near Weston, recently destroyed by fire. Loss close to $70,000, including equipment.

Mo., Carrollton—City Council is considering a report made by Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer, for new municipal electric light and power plant, estimated to cost $235,000, with equipment. Proposed to arrange financing through Federal aid. A project for a new municipal waterworks, with pumping station and other structures, also is under consideration, and report has been made by engineer noted, with estimated cost placed at $165,000.

Neb., Alliance—City Council has plans under way for addition to municipal electric light and power plant, including installation of new turbo-generator unit and auxiliary equipment, boiler unit, pumping machinery and auxiliary equipment. Cost estimated close to $330,000. Financing will be arranged through Federal aid. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

N. Y., Buffalo—Wickwire-Spencer Steel Co., 41 East Forty-second Street, New York, N. Y., plans installation of electric power equipment in new one-story wire mill at main plant on River Road, Buffalo. Proposed to begin work soon. Entire project will cost about $500,000.

N. C., Fayetteville—R. B. Minges, Fayetteville, plans installation of power equipment in new one-story beverage-bottling plant on local site. Work will begin soon. Entire project will cost about $45,000. Robert L. Clommer, Hickory, N. C., is architect in charge.

Ohio, Toledo—Coca-Cola Bottling Co., 1235 Summit Street, plans installation of power equipment in new one and two-story bottling plant at 201 Sylvania Avenue. Entire project will cost close to $145,000. Work is scheduled to begin at once. C. B. Elliott is general manager.

Okla., Cordell—City Council plans extensions and improvements in municipal electric light and power plant, including installation of additional equipment. Cost estimated close to $60,000. Financing will be arranged through Federal aid. V. V. Long, Colcord Building, Oklahoma City, Okla., are consulting engineers.

Okla., Fairfax—Common Council is considering new municipal electric light and power plant. Cost about $150,000, with engine-generator units and auxiliary equipment. Financing is being arranged through Federal aid. George E. Chambers, mayor, is active in project.

Ore., Hood River—Hood River Apple Growers Association plans installation of electric power equipment in new packing plant, to replace building destroyed by fire a few months ago, with loss of about $100,000. Also will install conveying and other mechanical-handling equipment. Work on superstructure has been authorized at once. Entire project will cost approximately amount of fire loss. W. Q. Bateman is manager.

Texas, Abilene—City Council plans construction of new electric-operated pumping station in connection with extensions in waterworks filtration plant and other improvements in water system. Entire project will cost about $400,000. Hawley, Freese & Nichols, Capps Building, Fort Worth, Tex., are consulting engineers.

Texas, Lufkin—Southland Paper Mills, Inc., Lufkin, E. L. Kurth, head of Angelina Lumber Co., Lufkin, president, recently organized, plans power house and pumping station at proposed new local newsprint mill, on which work is scheduled to begin this summer. Entire project will cost over $5,000,000. Financing has been arranged. George F. Hardy, 305 Broadway, New York, N. Y., is consulting engineer.

Va., Richmond—American Refrigeration Co., Inc., Fifteenth and Cary Streets, has approved plans for new multi-story ice-manufacturing and frosted food products plant on local site. Cost close to $700,000, with equipment. Proposed to begin erection soon. R. T. Lipscomb, Sr., 1425 East Main Street, Richmond, is consulting engineer.

Wash., Tacoma—Tacoma Sash & Door Co., Fifteenth and Dock Streets, plans installation of electric power equipment in new one-story plant for manufacture of sash, doors and other millwork products, to replace mill recently destroyed by fire, with loss estimated at close to $100,000. New plant will clost close to like sum.